Carrier Air Washers *and* Humidifiers

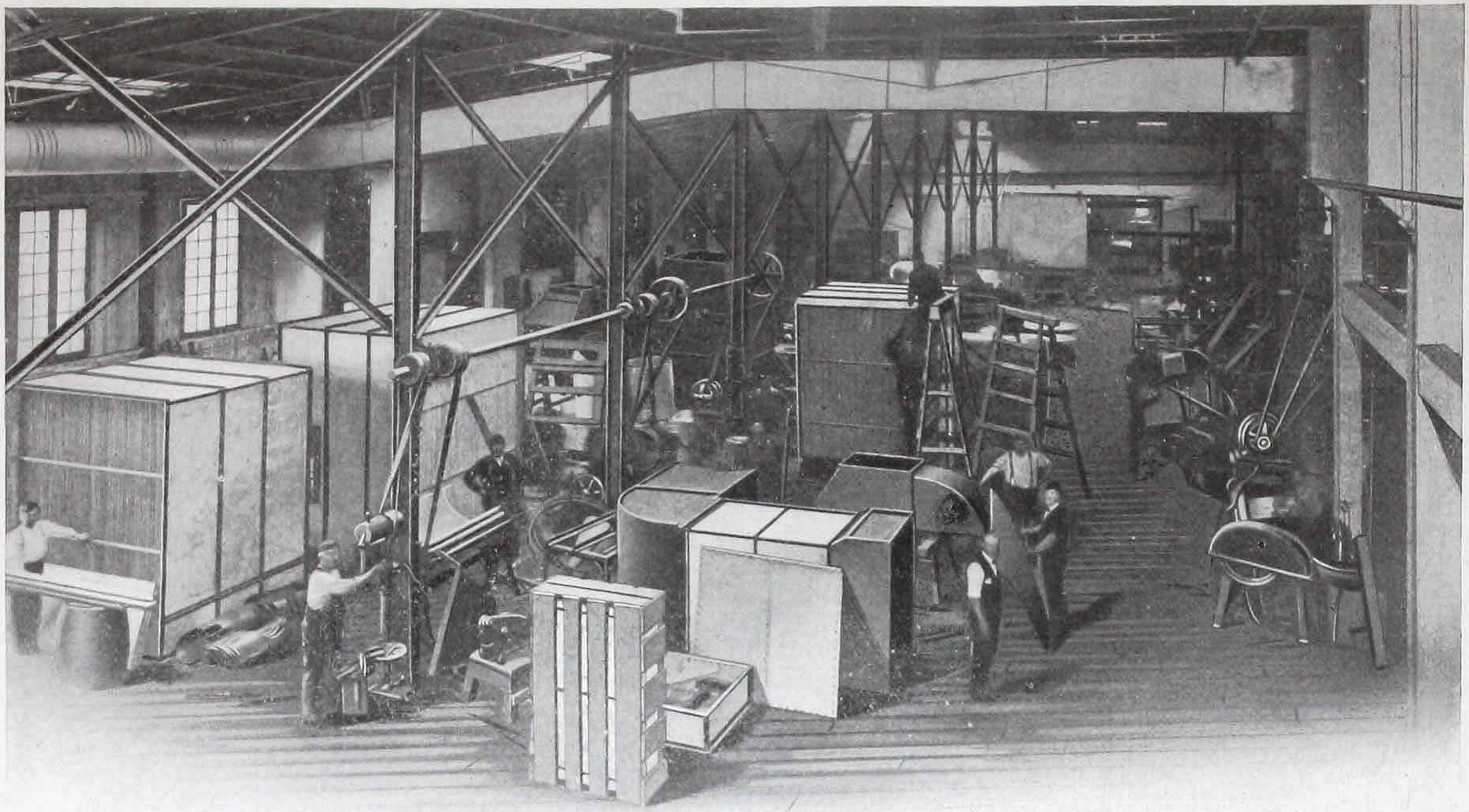
With Notes on Humidity

Patented in the United States
Canada and Foreign Countries

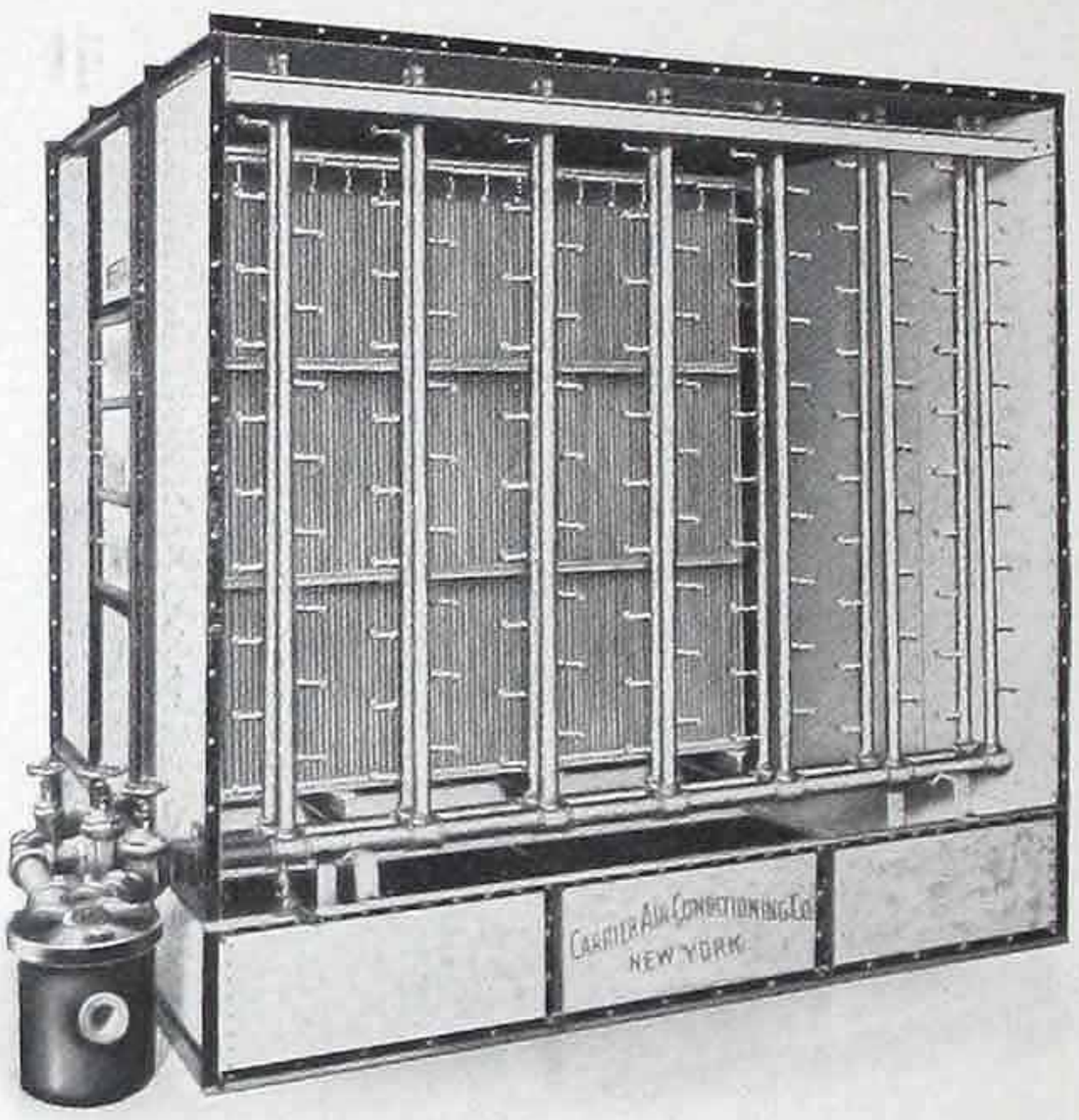
Carrier Air Conditioning Company
of America
39 Cortlandt Street, New York, N. Y.

Press of
ROBERT L.
STILLSON
COMPANY
NEW YORK

ID 90-B6245 TCF



Interior of Shop, showing Air Washers and Humidifiers under construction



Carrier Air Washer and Humidifier

Construction of Apparatus

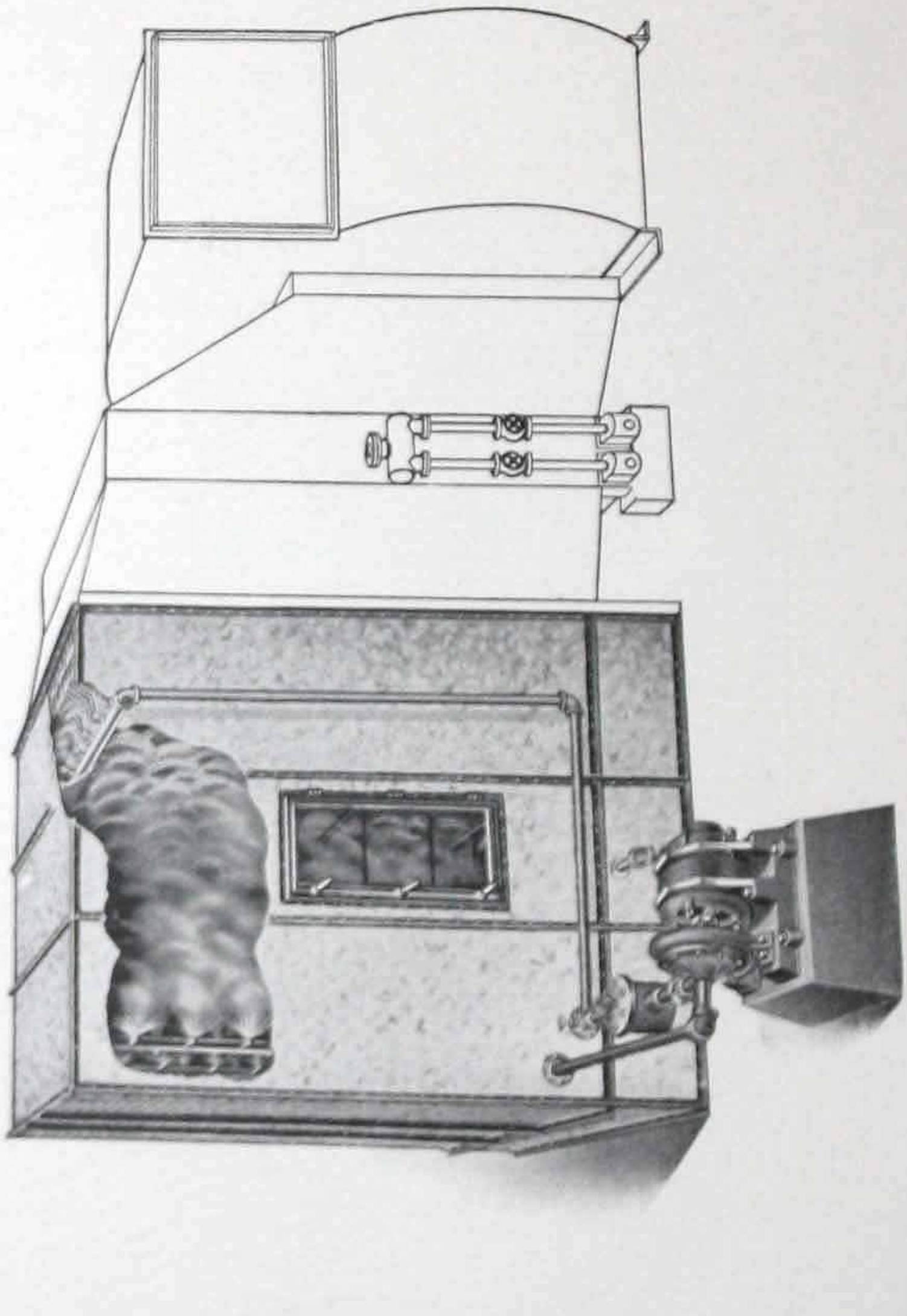
Testing Laboratory: By way of introduction to what follows, let us state, that in addition to the early experiments made when developing our apparatus, this Company had in operation for more than a year one of our latest types of humidifiers, upon which a series of tests have been made by a corps of competent engineers. Every possible condition that we have been able to conceive has been investigated. The test of each condition was extended over a considerable period of time, and from these tests we have accumulated the immense amount of data which has enabled us to determine all of the laws governing the washing, humidifying, dehumidifying, and the control of humidity by means of our apparatus.

We expect to maintain this Experimental Plant to investigate from time to time any special problems that have possibly been overlooked.

Our Staff: In addition to Mr. W. H. Carrier, the inventor of our systems and apparatus, and who is acknowledged to be one of the best, and possibly the best, informed engineer on the subject of humidity in this country today, we have in our employ a corps of engineers who are devoting their entire time to this one subject of air conditioning, which includes humidifying, dehumidifying, the controlling of humidity, washing and purifying of air, heating, ventilating and cooling. These engineers are at the disposal of our customers for the working out of any special problems which may come to hand.

Patents: The apparatus of the Carrier Air Conditioning Company of America is fully protected by American and Foreign Patents, which are basic in nature. We will vigorously defend our rights and protect our customers from any infringements.

Material Used: The Carrier Air Washers and Humidifiers are usually constructed of heavy galvanized iron assembled with galvanized rivets and bolts so as to be perfectly non-corrosive.



Carrier Air Washer and Humidifier, showing Sprays in operation

Regarding the life of our Standard Galvanized Washers and Humidifiers, the first washer constructed of this type has been in operation since 1903 and does not today show any signs of corrosion.

We use sheets with only the heaviest galvanizing, and it is certain that they will outlast one-half-inch plates of a boiler using the same water.

Copper Washers: For special installations they are often made of copper or special acid resisting metals. While for ordinary work this Company does not recommend the increased expenditure required for a copper washer, still we are pleased at any time to submit prices on apparatus built of any special metal.

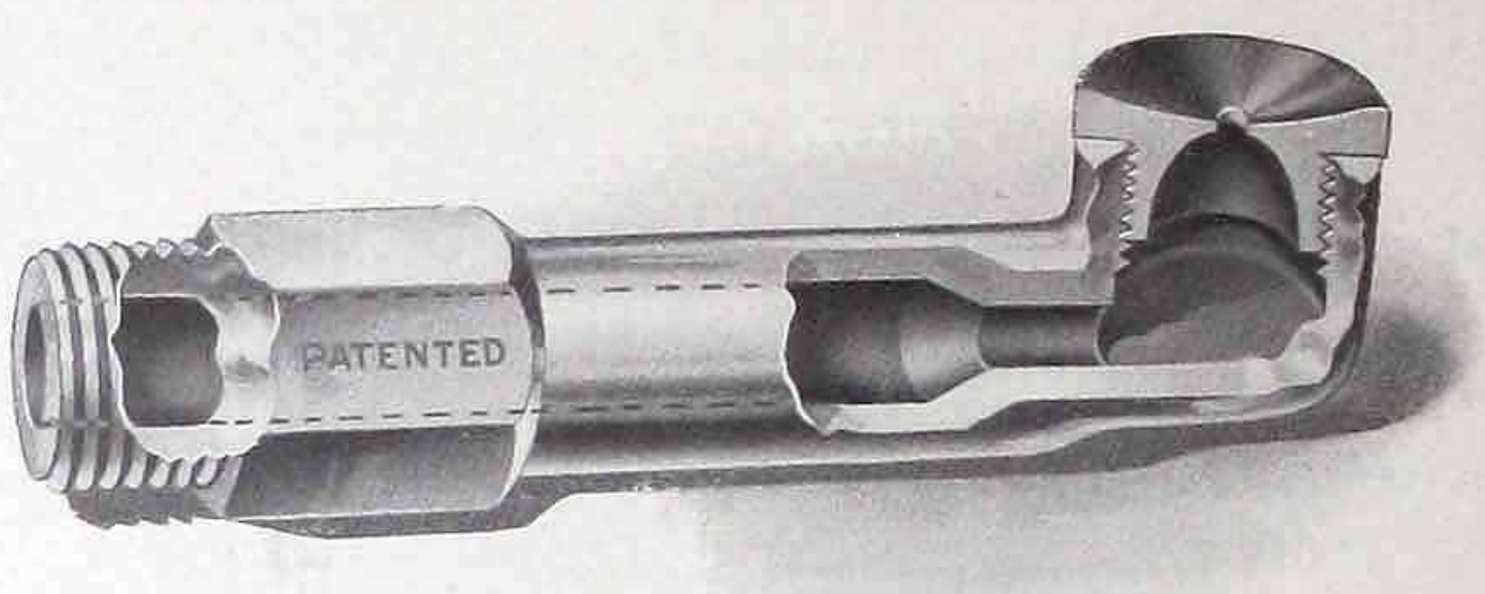
Spray Chamber and Casing: The Carrier Air Washer and Humidifier consists of a large chamber, the casing of which is usually built of galvanized iron, or copper, and strongly braced with angle irons placed on the outside of the galvanized sheets. The sheets are so arranged that with the soldered edges there is none of the iron which is unprotected; hence, there can be no corrosion or rust.

The air to be washed and humidified is drawn through this chamber and intimately brought in contact with a very finely divided or atomized spray. This spray so completely fills the chamber that it is impossible for the least particle of dirt to be drawn through the chamber without becoming moisture laden.

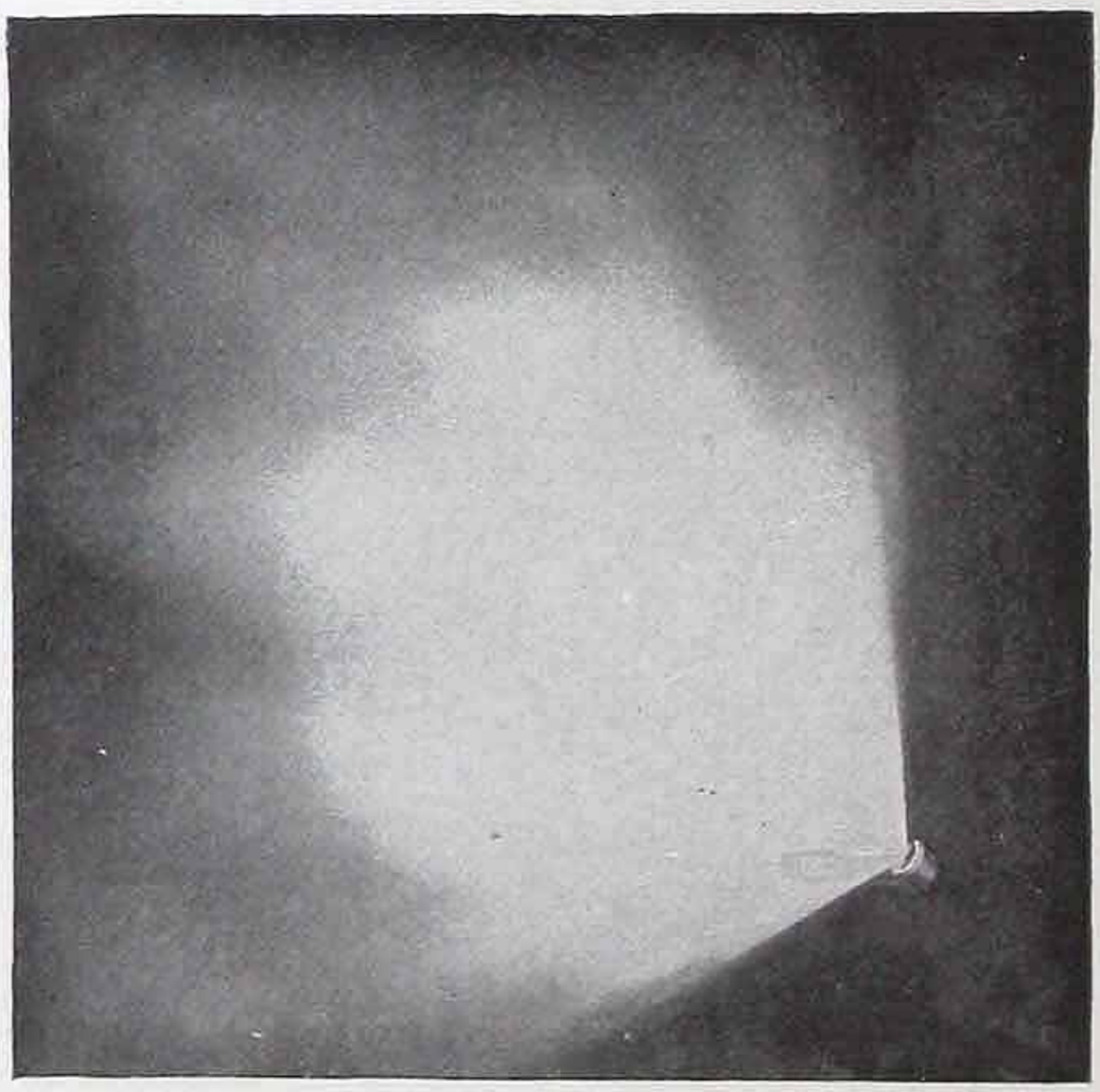
At the end at which the air leaves the spray chamber is placed an eliminator which removes all of the free moisture from the air, and as all of the dirt has previously become moisture laden, it is washed down the eliminator plates to the settling tank.

Settling Tank: The settling tank, which is placed under the entire washer and eliminator, is usually built of heavy galvanized iron properly braced with angle iron which is placed on the outside of the tank. This tank being of large area and holding considerable water, allows the dirt to settle to the bottom.

The tank is provided with an automatic float valve which controls the water supply to the tank and maintains a constant water level in it. It is also provided with an



Section of Spray Nozzle



Spray Nozzle in action

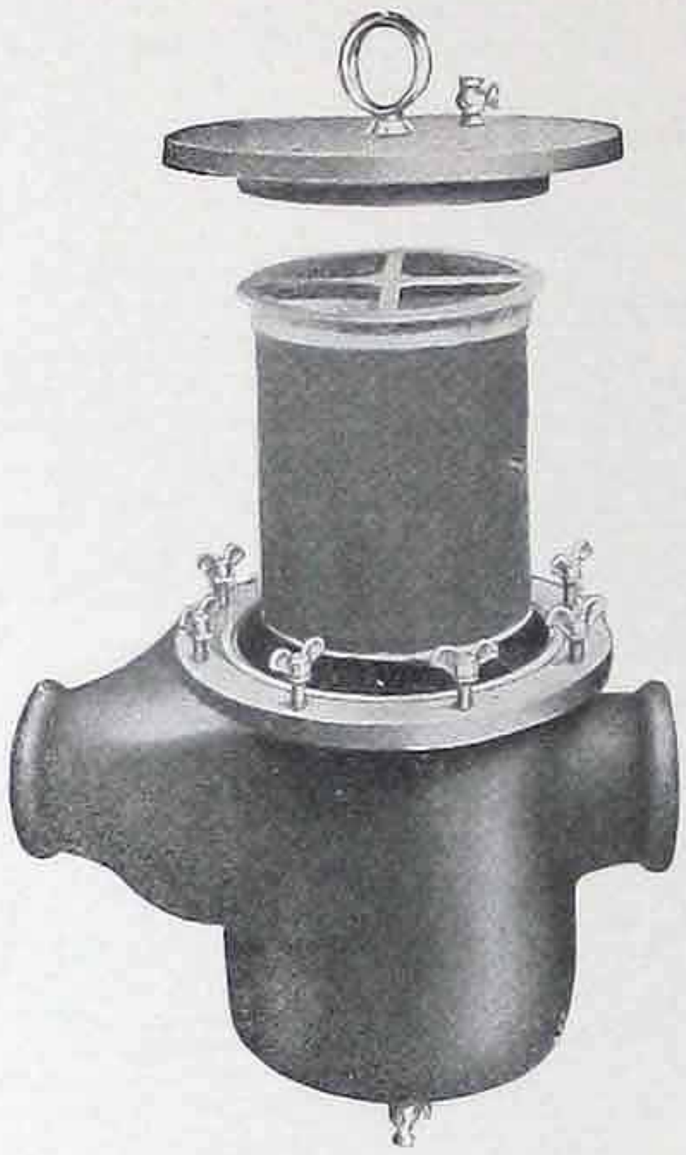
over-flow, which runs to the sewer, and which is a guarantee against the tank ever being flooded. In addition to this there is a flush-out cock arranged under the bottom of the tank, and which connects to the sewer, so all of the water may be drawn off, when occasion requires, and the entire tank washed out to free it of the dirt which has settled in it during operation.

Spray Nozzle: The Spray Nozzle, though most effective, is very simple in construction. The water enters a small circular chamber tangentially, which gives it a whirling or centrifugal action. The outlet or discharge opening is at the axis of rotation. The approach of the discharge opening is conical, shaped so the rotation, or whirling speed of the water, is greatly increased as it approaches the discharge. The effect of this arrangement is to give a most minutely divided or atomized spray, which offers an enormous amount of surface for evaporation.

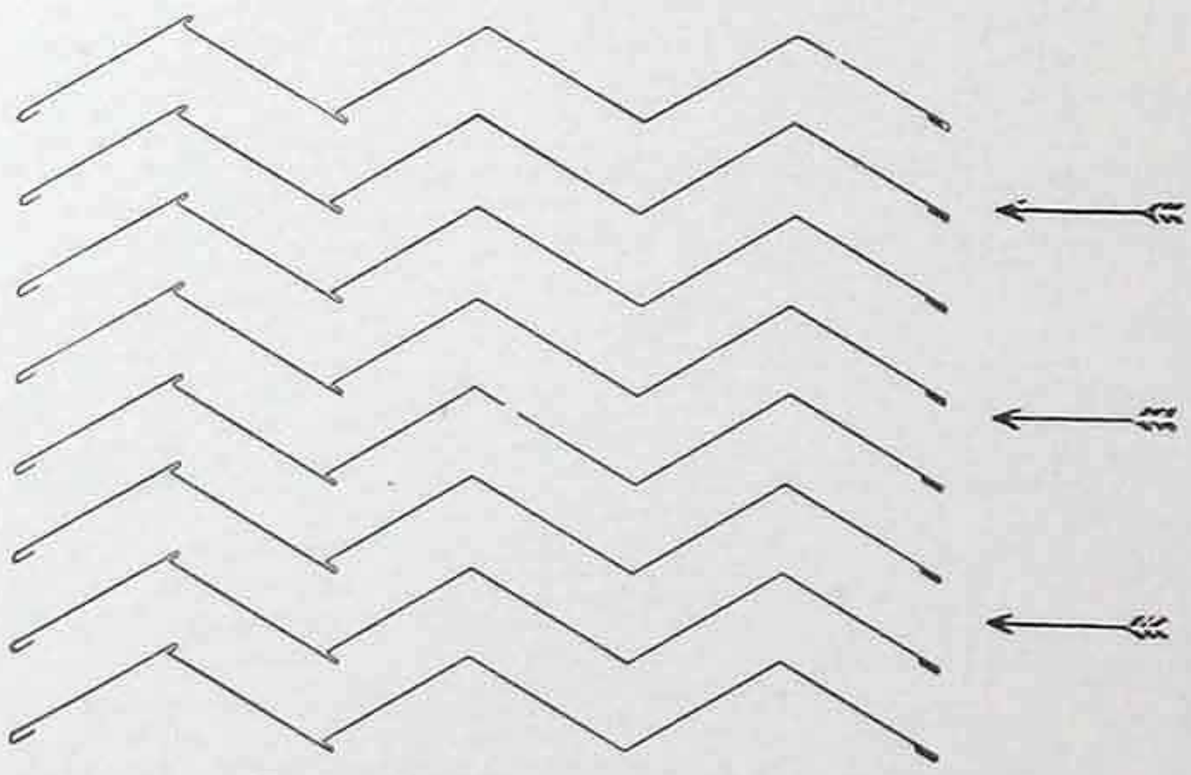
The construction of the nozzle is such that it is practically impossible to clog it with foreign material, the smallest hole being 3/32 of an inch in diameter, yet it throws a perfectly atomized mist, by reason of the centrifugal principle upon which it operates. Although the discharge opening in the nozzle is much larger than those in general use, still every precaution is taken to insure the removal of any lint or dirt from the water before it enters the spray piping.

The pressure required for complete atomizing of the water never exceeds twenty-five pounds per square inch, and which is about one-third of that required by most of the humidifying systems.

Eliminator Flooding Sprays are located near the top of the eliminators of Standard Air Washers and are so arranged that the first three corrugations of the eliminators are kept constantly flooded with a sheet of water which catches any solid matter, not already precipitated by the first set of sprays, and washes it to the settling tank. This flooding is used continuously but provision is made for shutting off the atomizing sprays in summer on very humid days. This arrangement provides a very good washing effect without materially increasing the already disagreeable humidity.



Basket Strainer and Pot



Strainers: In Standard Air Washers the water passes through two strainers, one a basket strainer placed in the discharge pipe between the pump and sprays, and the second placed across the end of the settling tank located under the spray chamber. This strainer offers a very large surface and is made of No. 16 mesh copper wire screen. The suction connection to the pump is made at the end of the tank, so the water must pass through this strainer before entering the pump.

Over the top of this suction space formed between the strainer and the end of the tank is placed a cover to prevent any dirt from falling in as the air passes over it. The lid is easily removed for cleaning the strainer when the tank is cleaned. The basket strainer screen, which is of 24 mesh copper, is very easily removed for cleaning by simply loosening the thumb nuts and lifting the strainer out and dumping the dirt.

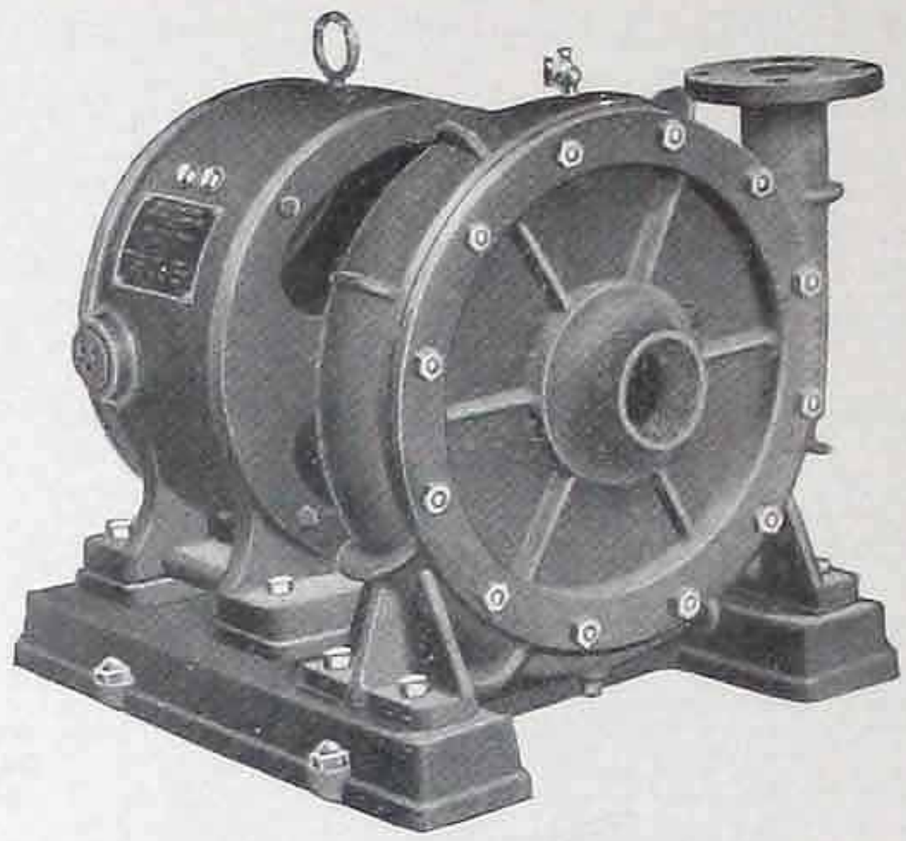
In those textile mills where a great deal of lint is present in the air, instead of the stationary suction screen just mentioned, an automatic rotary self-cleaning strainer is used. This strainer, which is carried on trunnions, revolves slowly, bringing each part in contact with a rotating brush, which effectually keeps the screen clear of all lint and dirt.

Eliminators: The eliminators are usually built of galvanized iron and are made up of a series of plates evenly placed and set in a vertical position across the discharge end of the spray chamber. It will be noted that each eliminator is made of a single sheet of galvanized iron so stamped as to form several corrugations, with three of the corrugations having lips projecting. The plates are held together with galvanized angles at top and bottom, and at intervals throughout the height, so as to keep them evenly spaced. All rivets and bolts used in the construction of the eliminators are galvanized, so that there is no chance of corrosion.

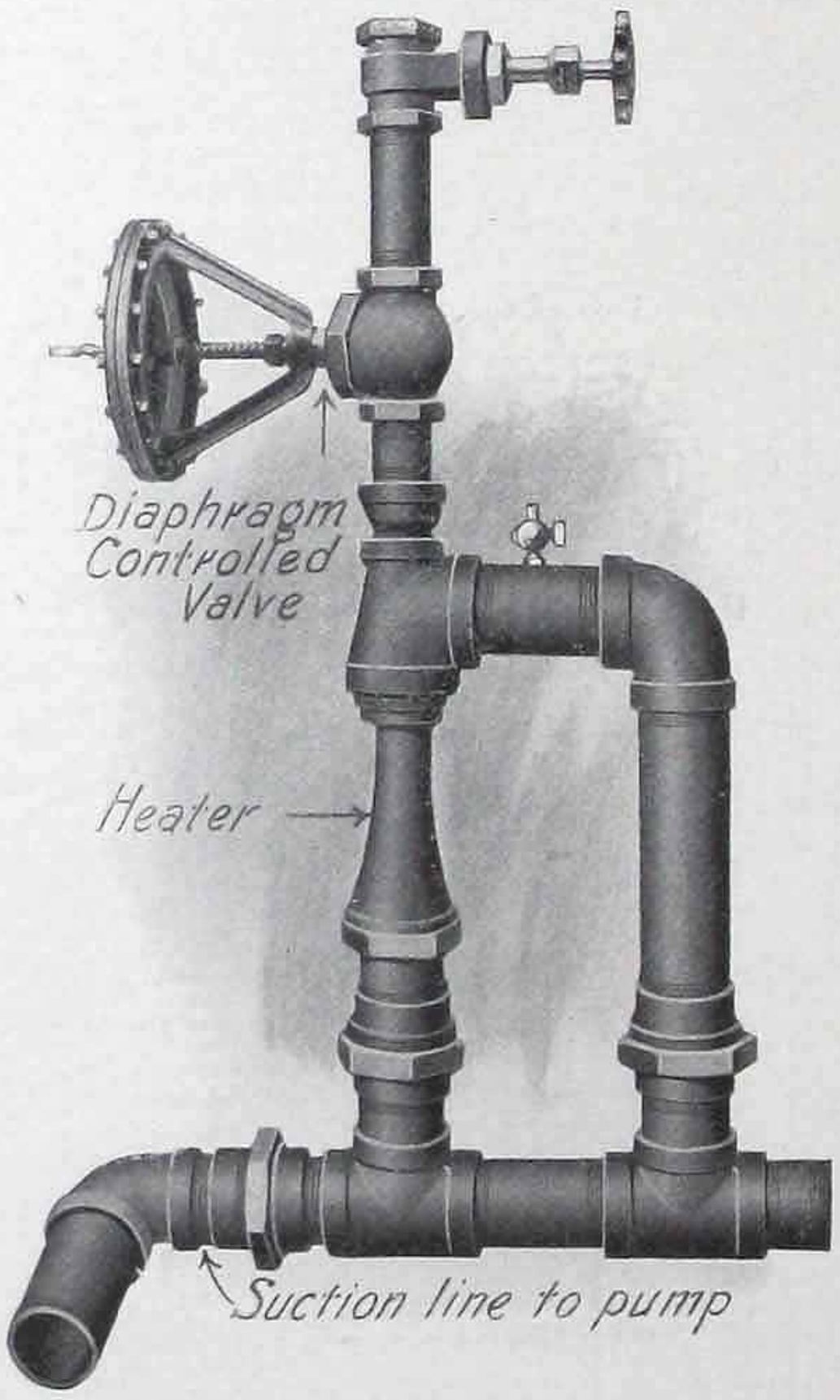
Owing to the methods used in the forming of the plates, and in holding them together, they are very rigid, without excessive weight, and are easily shipped.

The action of the eliminator is divided into two portions:—

1st. It is entirely covered with a sheet of running water precipitated from the spray laden air and from the flooding



Pump and Motor



Water Heater

sprays. The air impinges upon the water surface, and all solid particles are caught and washed away.

2d. The liplike projections prevent the free passage of water across the surface and form vertical gutters down which the water flows. Not the slightest trace of free moisture can be found in the air after passing through the eliminator, even with high velocities. The loss in pressure of the air in passing through the separator is inappreciable when standard proportions are used.

Pump: The pump used is one especially designed for the work. It is of the centrifugal type with an enclosed runner or impeller.

The impeller is made in two parts, split at right angles to the length of shaft, which allows the water passages to be finished and the parts are afterwards riveted together.

No stuffing boxes are used, as a special form of leather cup packing is inserted which can be easily renewed, and which completely prevents any short circulating of the water within the pump. These two features produce a pump of a very high efficiency and one without valve or other mechanical troubles so usually found in pumping machinery.

The pump is preferably driven by a direct connected electric motor, but may be driven by a belt or other means most desirable.

Water Heater: As will be explained later, it is necessary to heat the water used in the washer and humidifier during winter, and on cool days of fall and spring. The water heater is built on the ejector principle, designed to operate without noise. It is simple, compact, and the most efficient device for heating water. With the Carrier Automatic Control the temperature is never raised above that required to give the results, so there can be no waste of steam.

The heater is placed on the suction line of the pump, so either high or low pressure steam above three pounds can be used.

Where vacuum systems of heating are used, steam at atmospheric pressure can be utilized for heating the water by use of a closed feed water heater. See illustration of the Luzerne County Courthouse installation, page 42.

Water Piping: All pipe and pipe fittings used for water or spray piping of standard washer or humidifier are the best galvanized iron pipe and galvanized fittings. Small valves are all brass, and large valves are iron body, brass fitted.

With copper washers and humidifiers nothing but brass piping and fittings are used.

The tables show the amount of piping furnished with standard machines. If any other relative location for the pump is desired, the purchaser must install the additional piping required.

Elimination of Tempering Coil: The heated water serves two functions:—

1st. It tempers or heats the air from the incoming temperature to the dew point desired. For public buildings the desired dew point is usually between 43° and 55° while in mills it may be as high as 75°. Thus the tempering coil necessary to heat the air from 0° to the dew point is eliminated. If it is desired to temper the air higher than the dew point temperature, then a small coil can be used just past the washer.

2d. The latent heat of evaporation is supplied to the water vapor absorbed by the air.

Controlling Humidity: By controlling the temperature of the air (or dew point) leaving the apparatus by means of the heated spray a much more accurate control is possible than by any other method. Our devices for controlling automatically either relative or absolute humidity are described in another catalog.

Location of Apparatus: The Carrier Air Washer and Humidifier is usually placed in the basement of the building and is connected to a regular Fan System of Heating Apparatus. This arrangement places the entire heating, cooling and humidifying apparatus in one location and under the care of one operator.

The centralization of all water and steam pipes at one point, in preference to scattering them throughout the building, recommends itself as compact and always within the ready observation of the operator.

The design of the apparatus permits observation of working parts at all times, is easily accessible, and requires but a small amount of attention.

Arrangement of Apparatus: In the design of the apparatus it is preferable to have the air washer and humidifier so placed that the fresh air taken from the outside, or the return air from the building, can be passed through it and then go to the heating coils and fan, from whence it is distributed under a slight pressure through the ducts to the different parts of the building.

Dampers should be provided to control the proportion of air returned from the building and the fresh air drawn from out of doors.

Fan and Ducts: The arrangement and construction of the ducts depend entirely upon the conditions to be met and results desired in each installation, so no specific rule can be given. However, it may be said, that for public buildings, office buildings, etc., there need be no change in the size of the fan or distribution of the ducts from that required to do the heating properly.

For installations in industrial plants, such as textile mills, etc., owing to the immense amount of heat generated within the building, and which must be absorbed by the incoming cool air in summer, it is necessary that the ducts be considerably larger than those usually installed for heating alone. All superintendents of this class of mills recognize that the heating of the building is a comparatively easy matter, but the cooling in summer is successfully accomplished in but few mills.

Notably the most successful of these installations are Carrier Systems.

Heater: Owing to the fact that a portion of the tempering or heating is done by the humidifier, a less number of heating coils is required. The heating demand upon the coils is very constant with the Carrier System, as the air leaves the humidifier at practically the same temperature throughout the entire winter.

Work Done by the Air Washer and Humidifier: The work done may be enumerated as follows:—

1st. The air is thoroughly washed, removing all solid matter and such gases and odors as are soluble in water.

2d. In Winter, no matter how cold the incoming air, it is tempered or heated to practically a constant temperature.

3d. The air is completely saturated in the humidifier, so by controlling the temperature at which the air leaves the humidifier, the dew point and number of grains of water vapor per cu. ft. entering the building, are controlled.

This temperature, which is automatically controlled, depends on the amount of moisture desired in the building. For instance, if the building temperature is maintained at 70° and 40 per cent. humidity, then the air would leave the humidifier at 43°. If 70° and 60 per cent. is required in the building, then the humidifier would deliver the air at $55\frac{1}{2}°$.

4th. The air in summer is cooled from 5° to 19°. This cooling is due to evaporation when using the water over and over again and will average about 14° during the hottest part of the summer days. Where cold water is available, almost any amount of cooling desired can be accomplished and the air dehumidified at the same time.

Operation: During the Winter the air is drawn through the air washer and humidifier where it comes in contact with the atomized spray of water which has been heated by the ejector. The spray washes and humidifies the air, which then passes through the eliminators where all the free or unabsorbed moisture and solid matter is removed. It then passes to the fan and tempering or heating coils to be heated sufficiently to maintain the required temperature in the building.

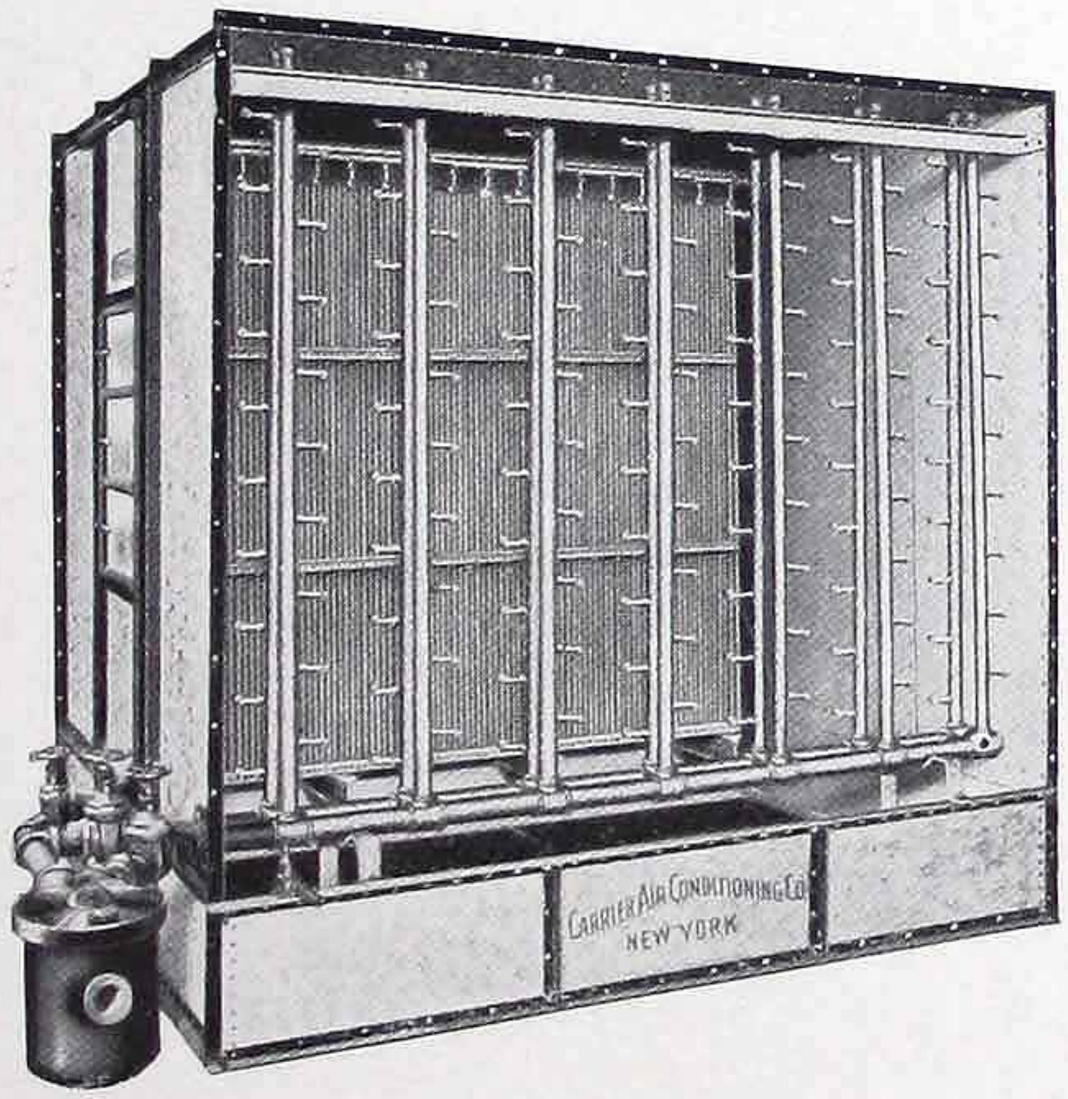
The spray water flows down the eliminator plates to the settling tank, passes through the suction screen, thence to ejector, where it is reheated, then to the pump and through the basket screen back to the sprays.

During the Summer the operation is exactly the same, except that no steam is used and the maximum cooling effect is procured.

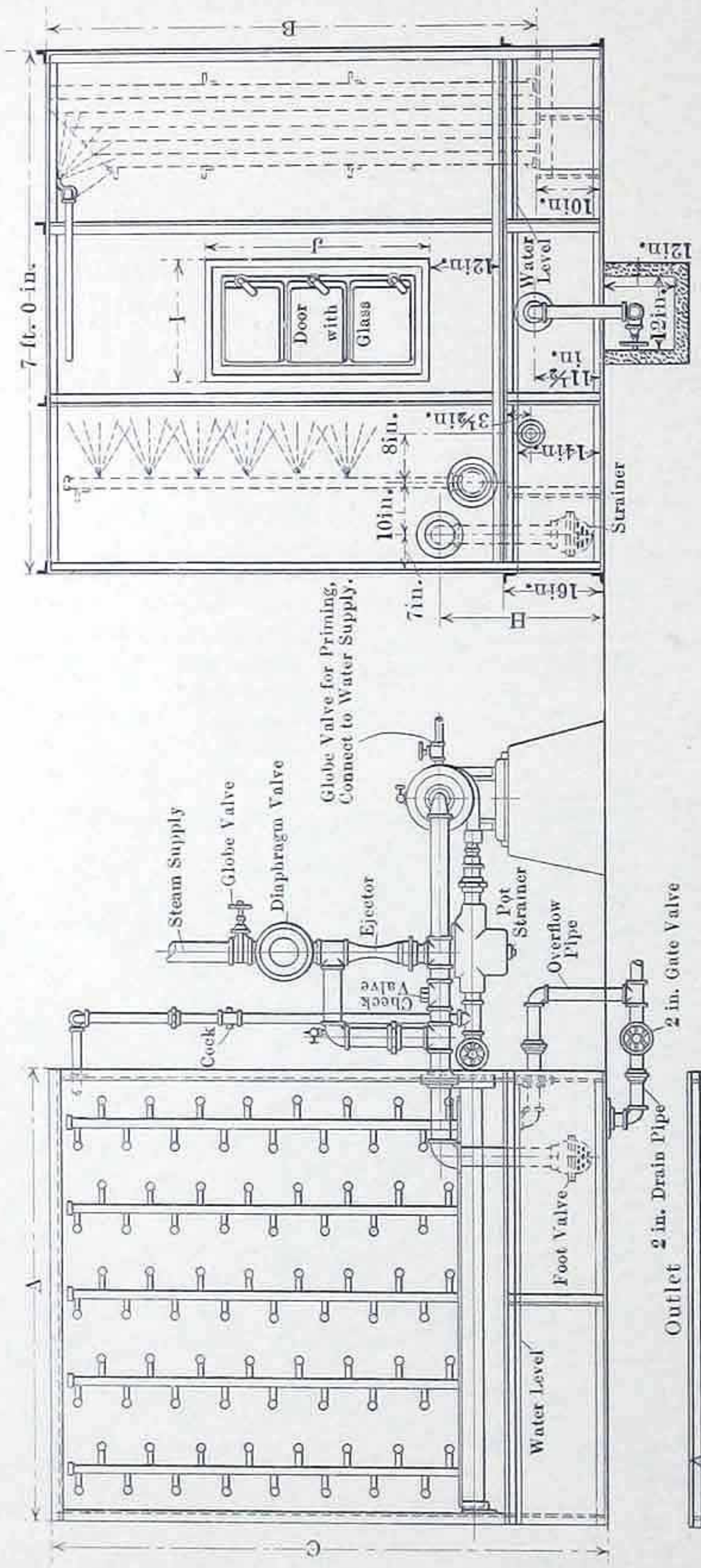
The Difference Between a Standard Air Washer and Humidifier: The Standard Air Washer is designed to meet the severest conditions to be found in school buildings, court houses, office buildings, etc. It will perfectly

cleanse the air at all times. In Winter it will maintain any percentage of humidity required up to 50 per cent. in a building heated to 70°. In Summer, while it will considerably cool the air it does not completely saturate it. It is designed to occupy the smallest space compatible with perfect operation, and offers a minimum amount of resistance to the passage of the air.

The Standard Humidifier cleanses the air at all times. It will give any required amount of humidity Winter or Summer up to 90%, and will cool the entering air to the outside wet bulb temperature in Summer, at which temperature it is completely saturated. The standard humidifiers are designed for all kinds of industrial installations, especially for textile mills.

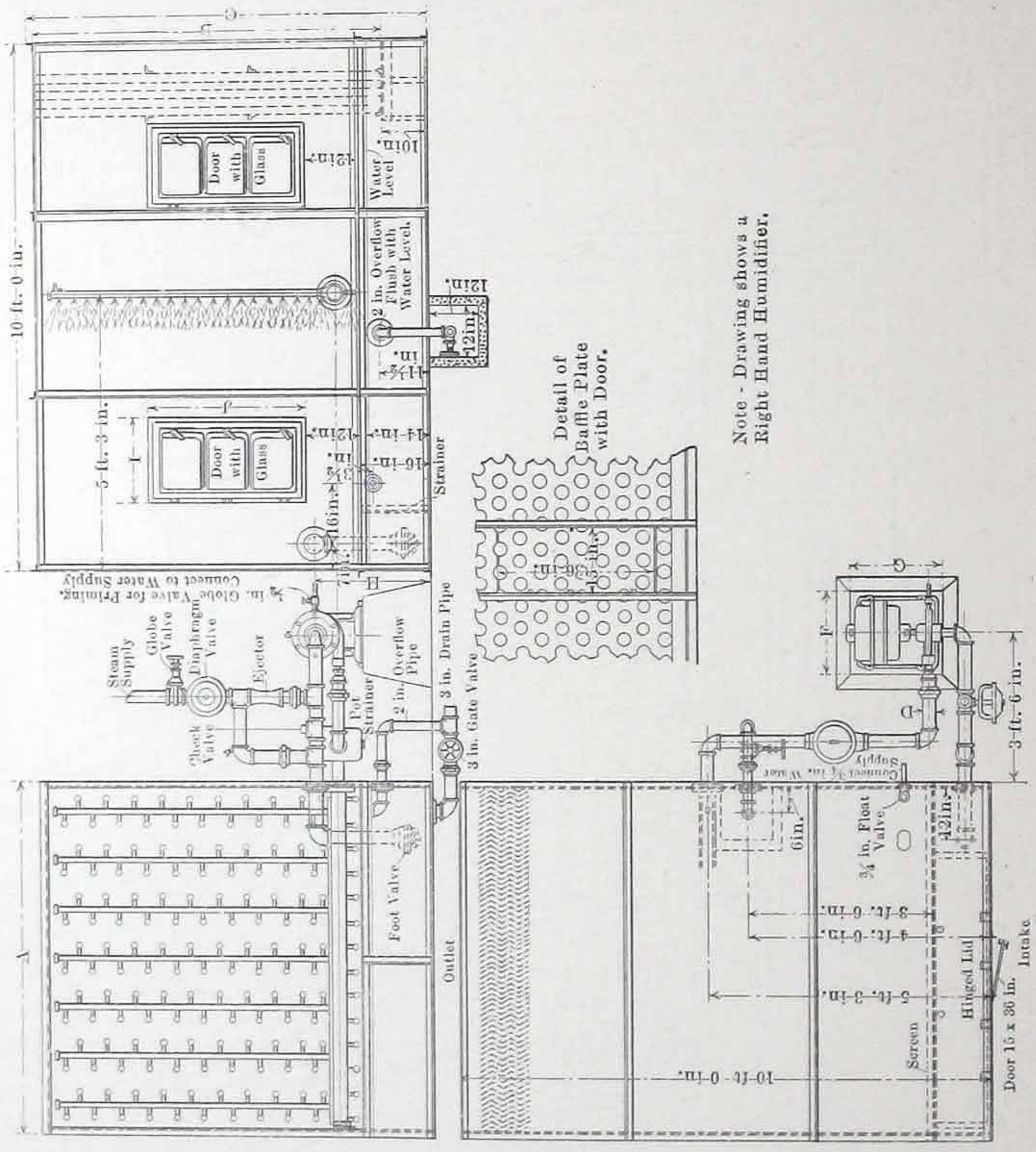


Arrangement of Sprays in the Carrier Air Washer and Humidifier


B
7-ft.-0-in.
Door with Glass
I
J
12in.
Water Level
10in.
11½ in.
12in.
12in.
3¾in.
14in.
8in.
10in.
7in.
16in.
H
Strainer
Globe Valve for Priming, Connect to Water Supply.
Steam Supply
Globe Valve
Diaphragm Valve
Ejector
Check Valve
Cock
Pot Strainer
Overflow Pipe
2 in. Gate Valve
Foot Valve
Water Level
Outlet
2 in. Drain Pipe
A
C
Connect ¾ in. Water Supply.
D
¾ in. Float Valve
2-ft.-6-in.
6in.
7-ft.-0-in.
Screen
Hinged Lid
Door 15 x 36 in.
Intake
4-ft.-6-in.
12in.
Note - Drawing shows a Right Hand Washer.
Detail of Baffle Plate with Door.
6in.
15in.

DIMENSIONS FOR CARRIER STANDARD AIR WASHERS WITH HUMIDITY CONTROL CONNECTIONS

No.	Cu. Ft. Air Per Min.	A Feet Inches	B Feet	C Feet Inches	D Inches	E Inches	F Feet Inches	G Feet Inches	H Feet Inches	I Feet Inches	J Feet Inches	Code
1—A	3500	2 — 7	3	3 —11½	1½	1½	2 — 2	2 — 3	2 — 1	1 — 6¾	2 — 1¾	Spadice
1—B	4650	2 — 7	4	4 —11½	1½	1½	2 — 2	2 — 3	2 — 1	1 — 6¾	2 — 1¾	Spæhne
1—C	7000	2 — 7	6	6 —11½	1½	1½	2 — 2	2 — 3	2 — 1	1 — 6¾	3 — 4	Spagade
2—B	7000	3 — 9	4	4 —11½	1½	1½	2 — 2	2 — 3	2 — 1	1 — 6¾	2 — 1¾	Spalava
2—C	10500	3 — 9	6	6 —11½	2	2	2 — 3½	2 — 4½	2 — 1 3/16	1 — 6¾	3 — 4	Spalax
2—D	14000	3 — 9	8	8 —11½	2	2	2 — 3½	2 — 4½	2 — 1 3/16	1 — 6¾	3 — 4	Spalco
3—C	14000	4 — 11	6	6 —11½	2	2	2 — 3½	2 — 4½	2 — 1 3/16	1 — 6¾	3 — 4	Spaltiger
3—D	18650	4 — 11	8	8 —11½	2	2	2 — 3½	2 — 4½	2 — 1 3/16	1 — 6¾	3 — 4	Spanader
3—E	23300	4 — 11	10	10 —11½	2	2	2 — 3½	2 — 4½	2 — 1 3/16	1 — 6¾	3 — 4	Spangle
4—C	17500	6 — 1	6	6 —11½	2	2	2 — 3½	2 — 4½	2 — 1 3/16	1 — 6¾	3 — 4	Spanhout
4—D	23300	6 — 1	8	8 —11½	2	2	2 — 3½	2 — 4½	2 — 1 3/16	1 — 6¾	3 — 4	Spaniol
4—E	29100	6 — 1	10	10 —11½	2	2	2 — 3½	2 — 4½	2 — 1 3/16	1 — 6¾	3 — 4	Sparagi
5—D	28000	7 — 3	8	8 —11½	2	2	2 — 3½	2 — 4½	2 — 1 3/16	1 — 6¾	3 — 4	Sparagon
5—E	35000	7 — 3	10	10 —11½	2½	2½	2 — 4	2 — 6	2 — 2⅛	1 — 6¾	3 — 4	Sparkish
6—D	32650	8 — 5	8	8 —11½	2½	2½	2 — 4	2 — 6	2 — 2⅛	1 — 6¾	3 — 4	Sparofen
6—E	40800	8 — 5	10	10 —11½	2½	2½	2 — 4	2 — 6	2 — 2⅛	1 — 6¾	3 — 4	Sparsile
7—D	37250	9 — 7	8	8 —11½	2½	2½	2 — 4	2 — 6	2 — 2⅛	1 — 6¾	3 — 4	Sparuto
7—E	46640	9 — 7	10	10 —11½	2½	2½	2 — 4	2 — 6	2 — 2⅛	1 — 6¾	3 — 4	Spasshaft
8—D	42000	10 — 9	8	8 —11½	2½	2½	2 — 4	2 — 6	2 — 2⅛	1 — 6¾	3 — 4	Spasticus
8—E	52500	10 — 9	10	10 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Spattle
9—D	46640	11 — 11	8	8 —11½	2½	2½	2 — 4	2 — 6	2 — 2⅛	1 — 6¾	3 — 4	Spatz
9—E	58300	11 — 11	10	10 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Spectral
10—D	51300	13 — 1	8	8 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Spananto
10—E	64150	13 — 1	10	10 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Spedale
11—D	56000	14 — 3	8	8 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Speidel
11—E	70000	14 — 3	10	10 —11½	3½	4	2 — 5½	2 — 9½	2 — 7	1 — 6¾	3 — 4	Speisen
12—D	60650	15 — 5	8	8 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Speothes
12—E	75800	15 — 5	10	10 —11½	3½	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Sperico
13—D	65300	16 — 7	8	8 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Sphex
13—E	81650	16 — 7	10	10 —11½	3½	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Spiani
14—E	87500	17 — 9	10	10 —11½	4	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Spielart
15—E	93300	18 — 11	10	10 —11½	4	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Spilkop
16—E	99150	20 — 1	10	10 —11½	4	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Spitons
17—E	105000	21 — 3	10	10 —11½	4	4	2 — 5½	2 — 9½	2 — 7	1 — 6¾	3 — 4	Spolier
18—E	110800	22 — 5	10	10 —11½	4	4	2 — 5½	2 — 9½	2 — 7	1 — 6¾	3 — 4	Sprevi



Note - Drawing shows a Right Hand Humidifier.

DIMENSIONS FOR CARRIER STANDARD HUMIDIFIERS WITH HUMIDITY CONTROL CONNECTIONS

No.	Cu. Ft. Air Per Min.	A	B	C	D	E	F	G	H	I	J	Code
		Feet Inches	Feet	Feet Inches	Inches	Inches	Feet Inches	Feet Inches	Feet Inches	Feet Inches	Feet Inches	
51—A	4025	2 — 2	3	3 —11½	1½	1½	2 — 2	2 — 3	2 — 1	1 — 6¾	2 — 1¾	Stablos
51—B	5481	2 — 2	4	4 —11½	1½	1½	2 — 2	2 — 3	2 — 1	1 — 6¾	2 — 1¾	Stabuli
51—C	8050	2 — 2	6	6 —11½	1½	1½	2 — 2	2 — 3	2 — 1	1 — 6¾	3 — 4	Staculum
52—B	8050	3 — 1½	4	4 —11½	1½	1½	2 — 2	2 — 3	2 — 1	1 — 6¾	2 — 1¾	Stagfock
52—C	12060	3 — 1½	6	6 —11½	2	2	2 — 3½	2 — 4½	2 — 1 3/16	1 — 6¾	3 — 4	Stagiros
52—D	16100	3 — 1½	8	8 —11½	2	2	2 — 3½	2 — 4½	2 — 1 3/16	1 — 6¾	3 — 4	Stagnoso
53—C	16100	4 — 1	6	6 —11½	2	2	2 — 3½	2 — 4½	2 — 1 3/16	1 — 6¾	3 — 4	Stalziek
53—D	21462	4 — 1	8	8 —11½	2	2	2 — 3½	2 — 4½	2 — 1 3/16	1 — 6¾	3 — 4	Stambha
53—E	26831	4 — 1	10	10 —11½	2½	2½	2 — 4	2 — 6	2 — 2⅛	1 — 6¾	3 — 4	Stamburo
54—C	20000	5 — ½	6	6 —11½	2	2	2 — 3½	2 — 4½	2 — 1 3/16	1 — 6¾	3 — 4	Stampata
54—D	26600	5 — ½	8	8 —11½	2½	2½	2 — 4	2 — 6	2 — 2⅛	1 — 6¾	3 — 4	Stangono
54—E	33250	5 — ½	10	10 —11½	2½	2½	2 — 4	2 — 6	2 — 2⅛	1 — 6¾	3 — 4	Stato
55—D	32200	6 — 0	8	8 —11½	2½	2½	2 — 4	2 — 6	2 — 2⅛	1 — 6¾	3 — 4	Staub
55—E	40250	6 — 0	10	10 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Staubweg
56—D	37600	6 —11½	8	8 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Stechring
56—E	46970	6 —11½	10	10 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Steekpan
57—D	42931	7 —11	8	8 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Stehpult
57—E	53662	7 —11	10	10 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Steilen
58—D	48300	8 —10½	8	8 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Stenoside
58—E	60400	8 —10½	10	10 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Stephusa
59—D	53620	9 —10	8	8 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Stethion
59—E	67100	9 —10	10	10 —11½	3½	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Stibi
60—D	59500	10 — 9½	8	8 —11½	2½	3	2 — 4½	2 — 8	2 — 5	1 — 6¾	3 — 4	Stilasco
60—E	73780	10 — 9½	10	10 —11½	3½	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Stiluro
61—D	64000	11 — 9	8	8 —11½	3½	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Stlata
61—E	79800	11 — 9	10	10 —11½	3½	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Stobros
62—D	69720	12 — 8½	8	8 —11½	3½	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Stokduif
62—E	87150	12 — 8½	10	10 —11½	3½	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Stookkas
63—D	75110	13 — 8	8	8 —11½	3½	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Stortvat
63—E	93870	13 — 8	10	10 —11½	3½	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Strabevo
64—E	100660	14 — 7½	10	10 —11½	3½	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Strapago
65—E	107310	15 — 7	10	10 —11½	3½	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Streit
66—E	114100	16 — 6½	10	10 —11½	3½	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Strucia
67—E	120750	17 — 6	10	10 —11½	3½	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Stueck
68—E	127470	18 — 5½	10	10 —11½	3½	4	2 — 5¼	2 — 9½	2 — 7	1 — 6¾	3 — 4	Styan

HUMIDITY

By J. I. Lyle, M. E.

Definition: Humidity is the water vapor (or moisture) mixed with the air in the atmosphere. It is now an accepted fact that the water vapor is simply mixed with the air and is entirely independent of the presence or absence of it. The weight of water vapor a given space will hold is entirely and only dependent on the temperature; that is, the amount of vapor is exactly the same whether the air is present or not. The air therefore simply affects the humidity by its temperature.

Water vapor does not spread so rapidly in air as in a vacuous space, as a certain amount of time is required for its diffusion.

For Example: Suppose that we have a vessel of one cu. ft. capacity, and that in this vessel is a perfect vacuum, and that it is placed in a room maintaining exactly and constantly a temperature around the vessel of say 70°. Now, if four grains of water are inserted into this chamber, it will rapidly evaporate, and this space will then have a relative humidity of 50 per cent. This vapor would fill the vessel, but if one cu. ft. of perfectly dry air at atmospheric pressure was forced into the vessel containing the water vapor, it would be found that the water vapor and air would so mix that the pressure in the vessel would still remain at atmospheric pressure and both gases would be contained in the space originally occupied by one.

Use of Terms: While the above is the accepted theory among scientists, and is really the only theory on which all of the phenomena of evaporation of water can be fully explained, still it is the common usage to consider that "air absorbs moisture." It was therefore considered best in submitting this publication to waive claims on scientific exactness of terms in favor of common usage. Use will be made of the accepted terms, namely, "the absorption of water by air," or "saturated air."

Absolute Humidity: Absolute Humidity is the weight of a cu. ft. of water vapor at a given temperature and per-

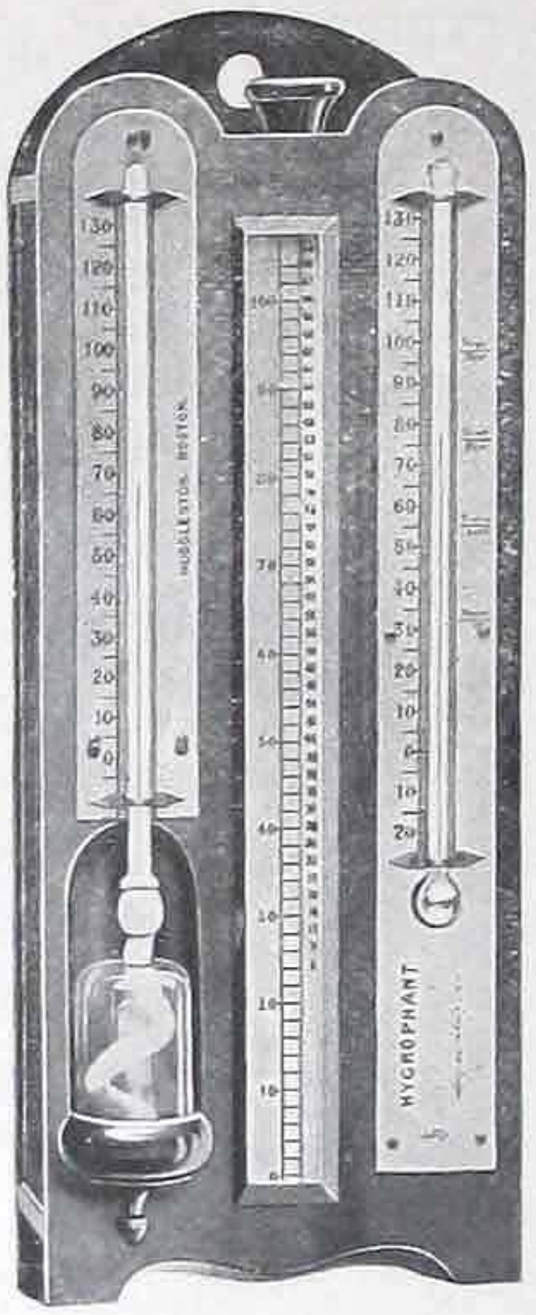
centage of saturation, and is usually expressed as grains per cu. ft. On page 34 is given a table of the amount of water vapor per cu. ft. at different temperatures and percentages of saturation.

Relative Humidity: Relative Humidity is the ratio of the weight of water vapor in a given space, to the weight which the same space will hold when fully saturated at the same temperature, and of course is expressed in percentage. Under normal conditions, the external air has a relative humidity varying from 50% to 75% of full saturation, and an absolute humidity depending upon external temperature. When the relative humidity is much above or below these limits, ill effects are experienced. The higher the temperature the more noticeable is the effect of moisture deficiency.

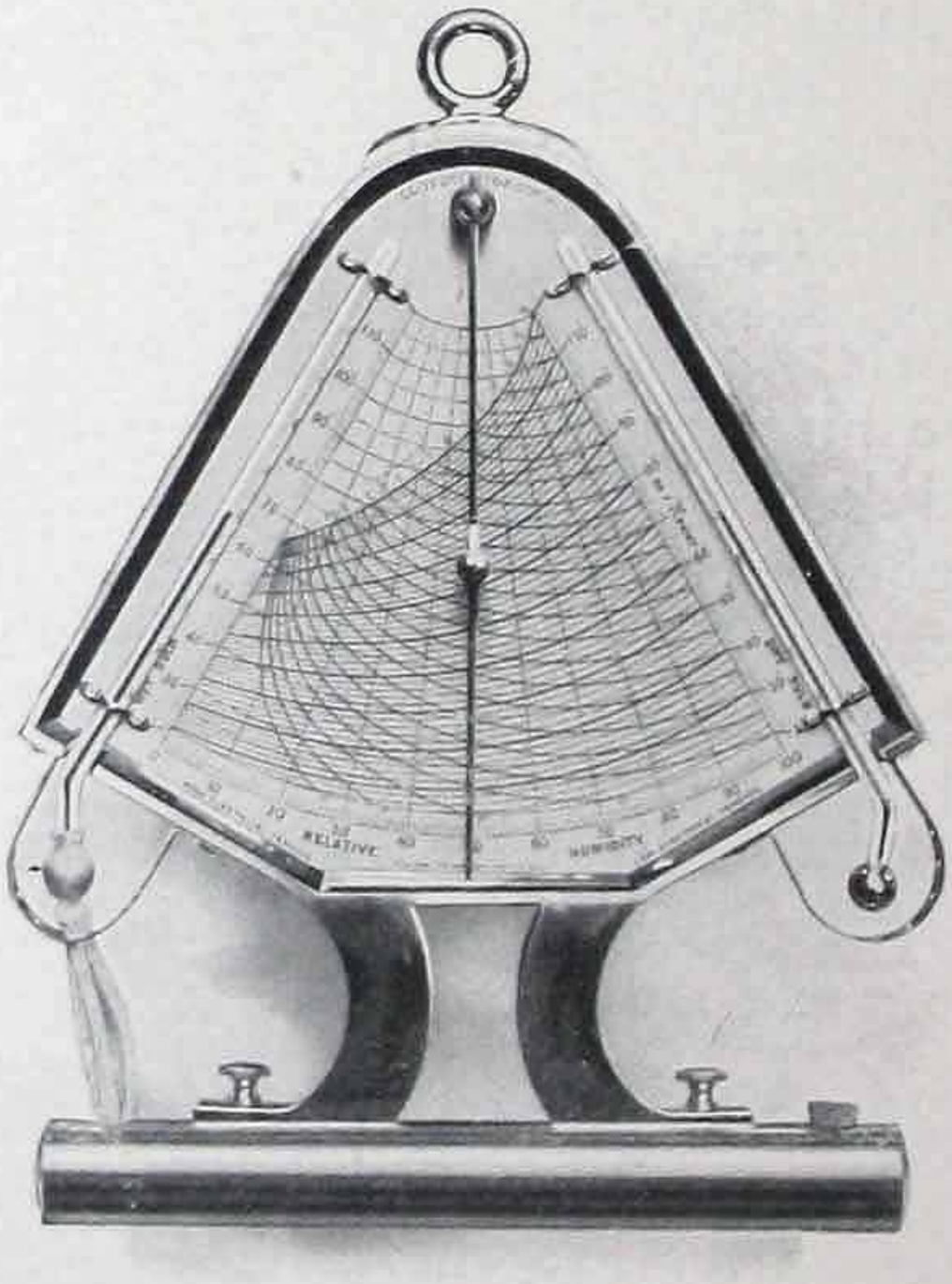
Dew Point: Dew Point is the temperature at which saturation is obtained for a given weight of water vapor. In other words, the dew point is the temperature where any reduction in temperature would cause condensation of some of the water vapor in form of dew particles. Any amount of moisture must have a dew point, for the temperature can always be so lowered that condensation must take place by any further reduction.

Measurement of Humidity: The quantity of moisture mixed with air under different conditions of temperature and degrees of saturation may be measured in several ways. Probably the most convenient of all methods, and the one generally employed, is to observe the temperatures of evaporation. This is the difference between temperature readings of the wet and dry bulb thermometers. Stationary thermometers in relatively stagnant air will not give accurate results. It is necessary that the thermometers be in a strong current of air.

Dry Bulb Thermometer: The dry bulb thermometer should be an accurate instrument preferably having the divisions marked on the glass tube of the thermometer. It should not be placed too close to the wet bulb, thereby preventing its being affected by the moist and cool air around the wet bulb.



Hygrophant



Hygrodeik

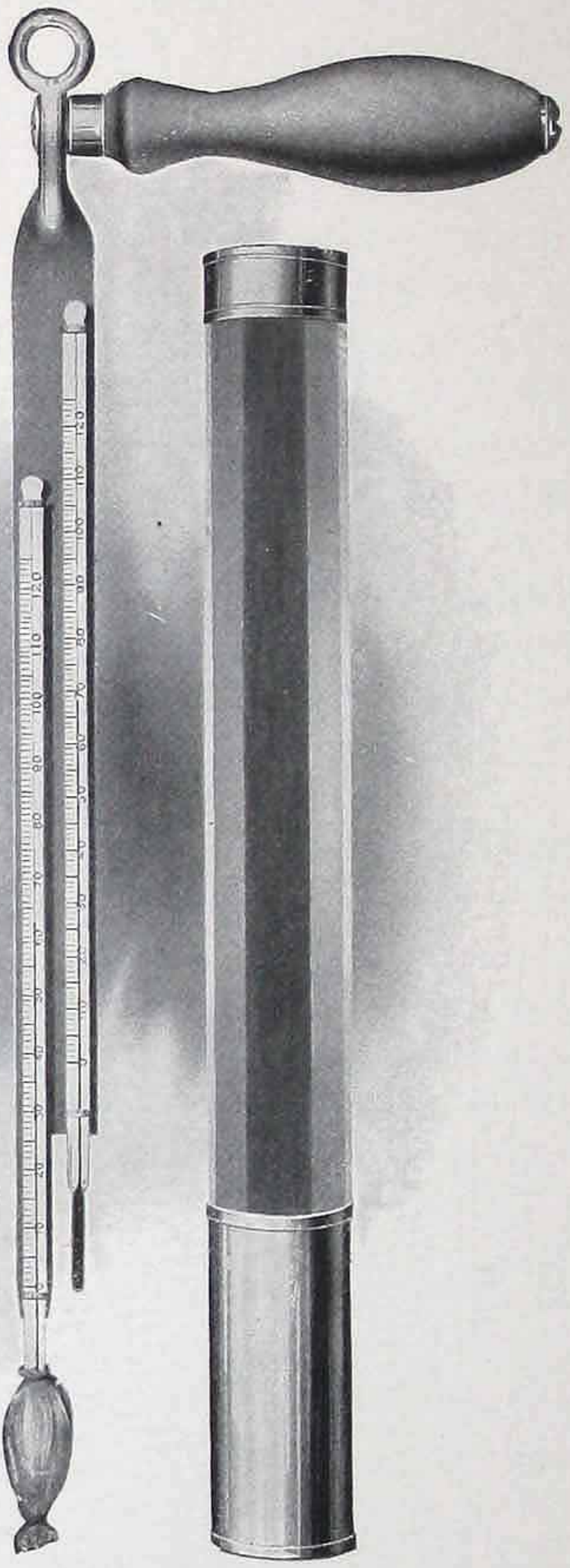
Wet Bulb Thermometer: The wet bulb thermometer, which gives a depressed reading in proportion to the evaporation therefrom, should be covered with soft muslin drawn tightly and neatly over it and thoroughly wetted in clean water. Clean muslin should be used as the evaporation of the water will soon leave in the meshes a small quantity of solid matter which stiffens it and prevents its ready absorption of moisture.

Hygrophant: There are various forms of stationary thermometer instruments on the market, any of which will give very accurate results if the air is agitated around them by means of a fan of some type, and if the wet and dry bulbs are not too close to each other. On page 24 is shown one type of these instruments.

Hygrodeik: While the hygrophant is the most common instrument used, the hygrodeik is very convenient, as the relative and absolute humidities can be read direct from the curves without further calculations.

The Sling Psychrometer: This instrument consists of a wet and dry bulb thermometer, provided with a handle, as shown on page 26, which permits of the thermometers being whirled rapidly. This instrument is convenient to use as it may be carried about a room or building by an observer and readings taken easily and rapidly. This is probably the most accurate instrument in general use, and is the one used by the United States Weather Bureau.

Relation of Wet Bulb to Dry Bulb Temperature: A careful study of the government psychrometric tables will show that the ratio of wet bulb temperature rise to dry bulb temperature rise is practically constant for any given percentage of humidity. For any range of temperature, for example, at 70° and 60% humidity, the wet bulb depression is 9°, and for each degree rise of the dry bulb, the wet bulb must rise .876 degrees in order to maintain the humidity constant at 60%. Similarly at 70°, 80% humidity, the wet bulb depression is $4\frac{1}{2}$°, and for each degree rise in the dry bulb, there must be a corresponding rise to .94 degrees in the wet bulb in order to maintain constantly 80% of humidity.



Sling Psychrometer

Relation of Dry Bulb, Wet Bulb and Dew Point: The relation between the temperature as shown by dry bulb and wet bulb thermometer, and their relation to the dew point, should be thoroughly understood by those expecting to become at all famil.ar with the requirements for the control of humidity.

Dew Point, as previously stated, is the temperature at which saturation is obtained for a given amount of water vapor. In other words, the air is at the dew point when it contains all the moisture that it will hold at a given temperature, and when it is impossible to get the air to absorb more water vapor without raising the temperature. When the air has been reduced to the dew point, it will be noted that both wet and dry bulb thermometers register exactly the same. *For instance:* Air at 50° temperature and 100% saturation will contain 4.076 grains of moisture per cu. ft. Under this condition the dry bulb thermometer and the wet bulb thermometer will both register 50°. If, however, the air is heated, both thermometers will rise, but the wet bulb temperature will rise more slowly.

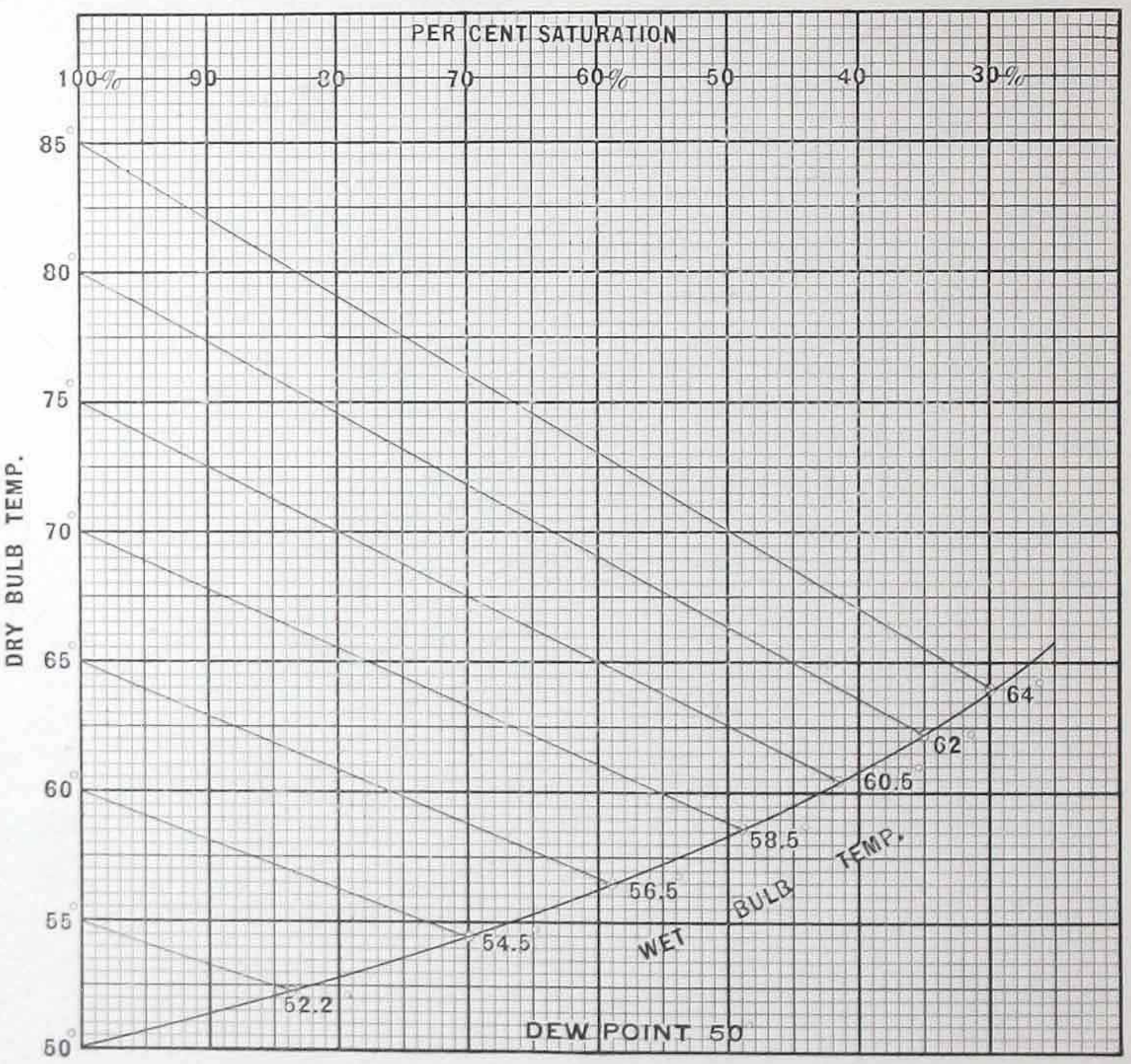
The following table shows the relative wet bulb, dry bulb and dew point temperatures in the above sample of air, if heated to the temperatures given:—

Dry Bulb.	Wet Bulb.	Dew Point.	Grs. of Moisture per Cu. Ft.	Relative Humidity or Per Cent. Saturation.
50°	50°	50°	4.076	100
56°	53°	50°	4.076	80
60°	54½°	50°	4.076	70
65°	57°	50°	4.076	60
70½°	59°	50°	4.076	50
77½°	62°	50°	4.076	40
87°	65°	50°	4.076	30

There are slight errors in the above figures, owing to the fact that the expansion of the air and vapor has not been taken into account, but as this is small, it may be neglected.

It will be noted that there is very much smaller rise in the wet bulb temperature than in the dry bulb, and that the dew point remains constant throughout.

For example: When the dry bulb temperature is at 65°, or a rise of 15°, the wet bulb has risen to 57°, or an increase of 7°. This gives a difference between the wet and dry bulbs of 65°–57°=8°, which corresponds to 60 per cent. saturation. As the dew point and the amount of moisture per cu. ft. bear a definite relation to one another, there being no change in the amount of moisture, the dew point remains unchanged.



The curve shows the relative increase in the wet and dry bulb temperatures in sample of air saturated at 50° and then heated. The dew point is a straight horizontal line; as there is no change in the amount of moisture, there can be no change in the dew point. The dry bulb and wet bulb temperatures corresponding are indicated

where the connecting angular lines intersect the curve. The relative humidity is shown at the top, and is read also from the curve.

Dew Point and Dry Bulb Temperatures: The relation of the dew point to the dry bulb temperature is both interesting and necessary to understand the methods of controlling humidity. This relation can be best illustrated by the following tables:—

1. Grains of water vapor per cubic foot held by an air when saturated at several temperatures.

Degrees.	Grains.
63	6.35
68	7.48
73	8.78
78½	10.11
82½	11.80

As the air is saturated, the temperatures given are the dew points for the various amounts of moisture. It is well to bear in mind that any given number of grains of moisture per cubic foot has a fixed and definite dew point or temperature of saturation.

2. Grains of water vapor per cubic foot held by air at 80% relative humidity at several temperatures.

Degrees.	Grains.
70	6.38
75	7.49
80	8.74
85	10.19
90	11.83

Now compare the weights given for the first temperature in each table. We find that air 80% saturated at 70° holds 6.38 grains per cubic foot, and that air at a dew point of 7° lower, or 63°, holds 6.35 grains, or practically the same amount.

By comparing the others in succession it will be found that air at 80% saturated holds the same amount of moisture per cubic foot as air approximately seven degrees lower in temperature but completely saturated.

It could similarly be shown that air 70% saturated contains the same weight of water vapor as air fully saturated $11\frac{1}{4}°$ lower.

From this can be seen, that if the difference between the dry bulb temperature and the dew point temperature remains almost constant, then the relative humidity will be practically constant even though the temperature may vary over quite a range.

Therefore, for relative humidity control it matters not what the dry bulb temperature is, nor the temperature of the dew point, but it depends upon the *difference between the two.*

The dew point depression below the dry bulb temperature for the different percentages of humidity is as follows:—

80%	approximately	7	degrees
75%	"	9	"
70%	"	$11\frac{1}{4}$	"
65%	"	$13\frac{1}{4}$	"
60%	"	$16\frac{1}{4}$	"
55%	"	19	"

When air is brought in contact with a cold surface the action is exactly the reverse of that given in the preceding discussion, except that if the surface is sufficiently cold, after the dry and wet bulb temperatures reach the dew point, then the dew point will be lowered and particles of water deposited on the surface.

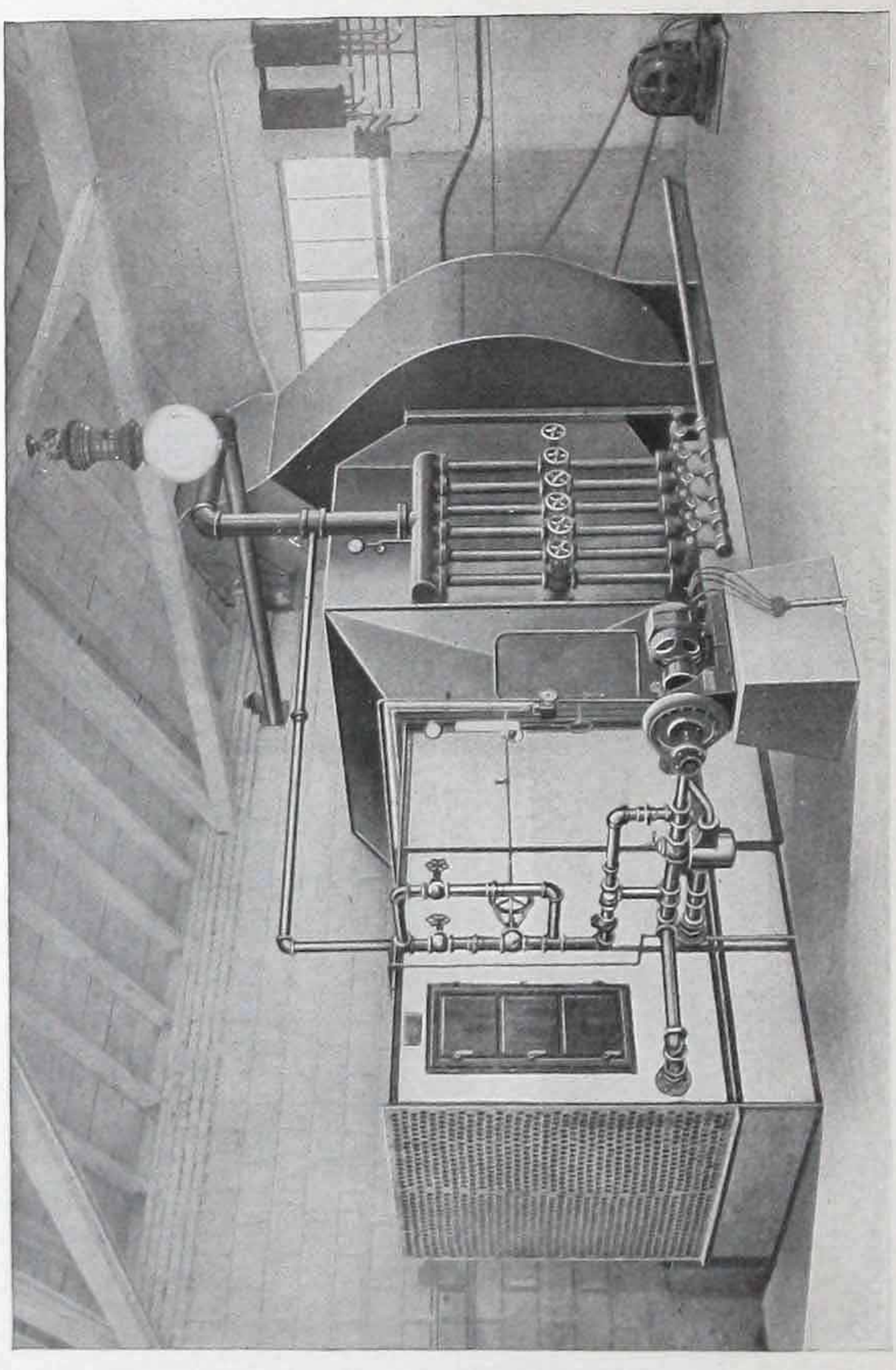
The Action of Wet and Dry Bulb Thermometers During Evaporation: If a cubic foot of air at a temperature of 87°, containing 4.076 grains per cu. ft., with the wet bulb temperature at 65°, is passed through a fine spray of heated water, the temperature of which is above 50°, it will absorb the moisture. It will be found then that the dry bulb temperature will immediately begin to fall, but the wet bulb temperature will remain absolutely constant at 65° until the dry bulb temperature has dropped to the wet bulb temperature, namely, 65°. As the absorption takes place of course the dew point will be gradually rising from 50° to 65° when saturation is obtained.

This table shows the relative temperature recorded by the thermometers during the absorption of moisture:—

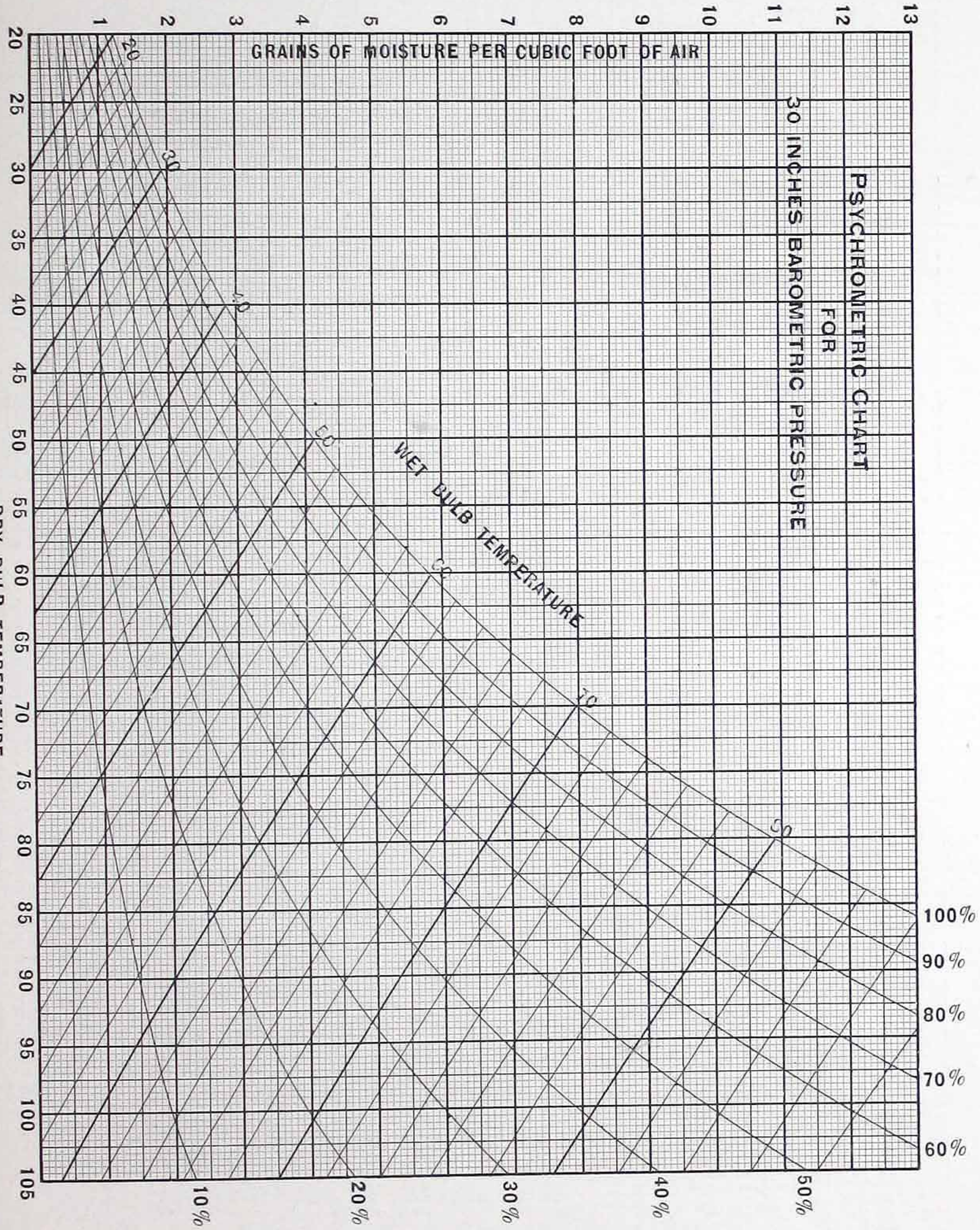
Dry Bulb.	Wet Bulb.	Dew Point.	Grs. of Moisture per Cu. Ft.	Relative Humidity or Per Cent. Saturation.
87°	65°	50°	4.08	30
82°	65°	55°	4.65	40
78°	65°	57°	5.13	50
75°	65°	59°	5.61	60
72°	65°	61°	5.96	70
69°	65°	63°	6.18	80
67°	65°	64°	6.52	90
65°	65°	65°	6.78	100

It will be noted in the first line of the table that with 4.08 grains of moisture per cu. ft. the dry bulb temperature was 87°, but the absorption of a little over one grain of moisture, increasing the amount to 5.13, lowered the dry bulb temperature to 78°; in other words, at the ordinary temperatures the absorption of one grain of moisture per cu. ft. lowers the dry bulb temperature approximately $8\frac{1}{2}°$.

Dehumidifying: If air is brought in contact with cold water in sufficient quantities, the temperature of the air will be reduced without absorption of moisture, due entirely to the transmission of the heat from the air to the water. In this case the dry bulb and wet bulb temperatures will both fall gradually until the dew point is reached, at which point, of course, both wet and dry bulb temperatures register the same. The temperature will then continue to fall, depending on the relative amount and temperature of water used; with a reduction of dew point, necessarily a certain amount of moisture will be given up by the air, thus lowering the dew point and reducing the number of grains contained in the air per cu. ft.



A Silk Mill Installation


PSYCHROMETRIC CHART
FOR
30 INCHES BAROMETRIC PRESSURE
GRAINS OF MOISTURE PER CUBIC FOOT OF AIR
1 2 3 4 5 6 7 8 9 10 11 12 13
20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105
DRY BULB TEMPERATURE
WET BULB TEMPERATURE
10 20 30 40 50 60 70 80
100%
90%
80%
70%
60%
10% 20% 30% 40% 50%
PER CENT SATURATION

Relative Humidity, Dew Points and Grains of Moisture per Cubic Foot for various Dry and Wet Bulb Temperatures of the Sling Psychrometer—Barometric Pressure, 30 Inches

Dry Bulb Temp.	Grains at Saturation	WET BULB DEPRESSION 1			2			3			4			5			6			7			8			9		
		%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins
0	.48	67	−7	.32	33	−20	.16																					
2	.53	70	−5	.37	39	−15	.21	9	−40	.05																		
4	.58	72	−2	.42	44	−11	.26	17	−28	.10																		
6	.64	74	0	.47	49	−8	.32	23	−21	.15																		
8	.70	76	3	.54	53	−5	.37	29	−15	.20	6	−42	.04															
10	.78	78	5	.61	56	−2	.44	34	−10	26	13	−27	.11															
12	.86	80	7	.69	59	2	.51	39	−6	.33	19	−19	.16															
14	.94	81	10	.76	62	5	.58	44	−2	.41	26	−12	.25	8	−33	.08												
16	1.03	82	12	.85	65	7	.65	48	+1	.50	31	−7	.32	14	−20	.15												
18	1.13	84	14	.95	68	10	.72	52	5	.59	36	−2	.41	20	−13	.23	5	−37	.06									
20	1.24	85	16	1.1	70	12	.86	55	8	.68	40	+2	.49	26	−7	32	12	−21	.15									
22	1.36	86	19	1.17	71	15	.96	58	11	.79	44	5	.60	31	−2	.42	17	−12	.23	4	−36	.05						
24	1.48	87	21	1.30	73	17	1.1	60	13	.89	47	9	.70	35	+2	.52	22	−6	.33	10	−20	.15						
26	1.62	87	23	1.41	75	20	1.22	63	16	1.02	51	12	.83	39	7	.63	27	−1	.44	16	−11	.26	4	−32	.07			
28	1.77	88	25	1.56	76	22	1.37	65	19	1.15	54	15	.96	43	10	.76	32	+4	.52	21	−4	.37	10	−17	.18			
30	1.94	89	27	1.72	78	25	1.5	67	21	1.30	56	18	1.08	46	14	.89	36	8	.70	26	+2	.50	16	−7	.31	6	−25	.12
32	2.11	89	30	1.88	79	27	1.67	69	24	1.46	59	21	1.25	49	17	1.03	39	12	0.82	30	7	0.63	20	−1	0.42	11	−12	0.23
34	2.28	90	32	2.05	81	29	1.85	71	26	1.62	62	23	1.41	52	20	1.19	43	16	0.98	34	11	0.78	25	5	0.57	16	−3	0.42
36	2.46	91	34	2.24	82	31	2.02	73	29	1.79	64	26	1.57	55	23	1.35	46	19	1.13	38	15	0.93	29	10	0.71	21	3	0.52
38	2.65	91	36	2.41	83	33	2.20	75	31	1.98	66	28	1.74	58	25	1.54	50	22	1.32	42	18	1.11	33	14	0.87	25	8	0.66
40	2.85	92	38	2.62	83	35	2.36	75	33	2.14	68	30	1.94	60	28	1.71	52	25	1.48	45	21	1.28	37	18	1.06	29	13	0.83
42	3.06	92	40	2.82	85	38	2.61	77	35	2.36	69	33	2.12	62	30	1.90	55	27	1.69	47	24	1.44	40	21	1.23	33	17	1.01
44	3.29	93	42	3.06	85	40	2.80	78	37	2.57	71	35	2.34	63	32	2.08	56	30	1.85	49	27	1.61	43	24	1.42	36	20	1.19
46	3.54	93	44	3.29	86	42	3.04	79	40	2.80	72	37	2.54	65	35	2.30	58	32	2.05	52	29	1.84	45	27	1.59	39	23	1.38
48	3.80	93	46	3.53	86	44	3.27	79	42	3.00	73	40	2.77	66	37	2.51	60	35	2.28	54	32	2.05	47	29	1.79	41	26	1.56
50	4.08	93	48	3.79	87	46	3.55	80	44	3.26	74	42	3.02	67	40	2.73	61	37	2.49	55	34	2.24	49	32	1.20	43	29	1.75
52	4.37	94	50	4.11	87	48	3.80	81	46	3.54	75	44	3.28	69	42	3.02	63	40	2.75	57	37	2.49	51	34	2.23	46	32	2.01
54	4.69	94	52	4.40	88	50	4.13	82	48	3.84	76	46	3.56	70	44	3.28	64	42	3.00	59	40	2.77	53	37	2.48	48	34	2.25
56	5.02	94	54	4.71	88	53	4.41	82	51	4.11	76	49	3.81	71	47	3.61	65	44	3.26	60	42	3.01	55	40	2.76	50	37	2.51
58	5.37	94	56	5.05	88	55	4.73	83	53	4.46	77	51	4.14	72	49	3.87	66	47	3 55	61	45	3.28	56	42	3.01	51	40	2.74
59	5.56	94	57	5.22	89	56	4.95	83	54	4.61	78	52	4.33	72	50	4.00	67	48	3.72	62	46	3.44	57	44	3.17	52	41	2.89
60	5.75	94	58	5.40	89	57	5.11	83	55	4.77	78	53	4.48	73	51	4.19	68	49	3.91	63	47	3.62	58	45	3.33	53	43	3.04
61	5.94	94	59	5.58	89	58	5.29	84	56	4.99	78	54	4.64	73	52	4.34	68	50	4.04	63	48	3.74	58	46	3.45	54	44	3.21
62	6.14	94	60	5.77	89	59	5.46	84	57	5.16	79	55	4.85	74	53	4.54	69	52	4.24	64	50	3.93	59	47	3.62	54	45	3.32
63	6.35	95	61	6.03	89	60	5.65	84	58	5.23	79	56	5.01	74	55	4.71	69	53	4.38	64	51	4.07	60	49	3.81	55	47	3.49
64	6.56	95	62	6.24	90	61	5.91	84	59	5.51	79	57	5.19	74	56	4.86	70	54	4.59	65	52	4.27	60	50	3.94	56	48	3.68

Relative Humidity, Dew Points and Grains of Moisture per Cubic Foot for various Dry and Wet Bulb Temperatures of the Sling Psychrometer—Barometric Pressure, 30 Inches

Dry Bulb Temp.	Grains at Saturation	WET BULB DEPRESSION 1			2			3			4			5			6			7			8			9		
		%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins
65	6.78	95	63	6.44	90	62	6.10	85	60	5.77	80	59	5.43	75	57	5.09	70	55	4.75	66	53	4.48	61	51	4.14	56	49	3.80
66	7.01	95	64	6.66	90	63	6.31	85	61	5.96	80	60	5.61	75	58	5.26	71	56	4.98	66	54	4.63	61	52	4.28	57	50	3.99
67	7.24	95	65	6.88	90	64	6.52	85	62	6.16	80	61	5.79	75	59	5.43	71	57	5.14	66	55	4.78	62	53	4.49	58	52	4.20
68	7.48	95	67	7.10	90	65	6.73	85	63	6.36	80	62	5.98	76	60	5.69	71	58	5.31	67	57	5.01	62	55	4.64	58	53	4.34
69	7.73	95	68	7.34	90	66	6.95	85	64	6.57	81	63	6.26	76	61	5.87	72	59	5.56	67	58	5.18	63	56	4.87	59	54	4.56
70	7.98	95	69	7.58	90	67	7.18	86	65	6.86	81	64	6.46	77	62	6.15	72	61	5.75	68	59	5 43	64	57	5.11	59	55	4.71
71	8.24	95	70	7.83	90	68	7.42	86	67	7.09	81	65	6.67	77	63	6.35	72	62	5.93	68	60	5.60	64	58	5.27	60	56	4.94
72	8.51	95	71	8.08	91	69	7.74	86	68	7.31	82	66	6.97	77	64	6.55	73	63	6.21	69	61	5.87	65	59	5.53	61	58	5.19
73	8.78	95	72	8.34	91	70	7.99	86	69	7.55	82	67	7.20	78	66	6.85	73	64	6.41	69	62	6.06	65	60	5.71	61	59	5.36
74	9.07	95	73	8.61	91	71	8.25	86	70	7.80	82	68	7.43	78	67	7.07	74	65	6.71	69	63	6.26	65	62	5.89	61	60	5.53
75	9.36	96	74	8.89	91	72	8.51	86	71	8.05	82	69	7.67	78	68	7.30	74	66	6.92	70	64	6.59	66	63	6.18	62	61	5.80
76	9.66	96	75	9.27	91	73	8.79	87	72	8.40	82	70	7.92	78	69	7.53	74	67	7.14	70	66	6.76	66	64	6.37	62	62	5.99
77	9.96	96	76	9.56	91	74	9.02	87	73	8.67	83	71	8.27	79	70	7.87	74	68	7.37	71	67	7.07	67	65	6.67	63	63	6.28
78	10.28	96	77	9.87	91	75	9.35	87	74	8.94	83	72	8.53	79	71	8.12	75	69	7.71	71	68	7.30	67	66	6.89	63	64	6.47
79	10.60	96	78	10.18	91	76	9.65	87	75	9.21	83	73	8.80	79	72	8.38	75	70	7.95	71	69	7.53	68	67	7.21	64	66	6.79
80	10.93	96	79	10.50	91	77	9.95	87	76	9.51	83	74	9.08	79	73	8.64	75	72	8.20	72	70	7.87	68	68	7.44	64	67	7.00
81	11.28	96	80	10.82	92	78	10.37	88	77	9 92	84	75	9.47	80	74	9.02	76	73	8.57	72	71	8.12	69	70	7.78	65	68	7.33
82	11.63	96	81	11.16	92	79	10.70	88	78	10.23	84	77	9.77	80	75	9.30	76	74	8.84	72	72	8.37	69	71	8.02	65	69	7.56
83	11.99	96	82	11.51	92	80	11.03	88	79	10.55	84	78	10.07	80	76	9.59	76	75	9.11	73	73	8.75	69	72	8.27	66	70	7.91
84	12.36	96	83	11.86	92	81	11.37	88	80	10.87	84	79	10.38	80	77	9.89	76	76	9.39	73	74	9.02	69	73	8.53	66	71	8.16
85	12.74	96	84	12.22	92	82	11.72	88	81	11.21	84	80	10.70	81	78	10.32	77	77	9.81	73	75	9.30	70	74	8.92	66	72	8.41
86	13.13	96	85	12.60	92	83	12.08	88	82	11.55	84	81	11.03	81	79	10.63	77	78	10.11	73	76	9.58	70	75	9.19	66	73	8.67
87	13.53	96	86	12.99	92	84	12.44	88	83	11.90	85	82	11.50	81	80	10.96	77	79	10.42	74	78	10.01	70	76	9.47	67	75	9.06
88	13.94	96	87	13.38	92	85	12.82	88	84	12.26	85	83	11.85	81	81	11.29	77	80	10.73	74	79	10.31	70	77	9.76	67	76	9.34
89	14.36	96	88	13.99	92	86	13.21	88	85	12.64	85	84	12.21	81	82	11.63	78	81	11.20	74	80	10.63	71	78	10.19	68	77	9.76
90	14.79	96	89	14.20	92	87	13.61	89	86	13.16	85	85	12.57	81	83	11.98	78	82	11.54	74	81	10.94	71	79	10.50	68	78	10.06
92	15.69	96	91	15.06	92	89	14.44	89	88	13.96	85	87	13.34	82	86	12.87	78	84	12.24	75	83	11.77	72	81	11.30	68	80	10.67
94	16.63	96	93	15.97	93	92	15.47	89	90	14.81	85	89	14.14	82	88	13.64	79	86	13.14	75	85	12.48	72	84	11.98	69	82	11.48
96	17.63	96	95	16.92	93	94	16.39	89	92	15.69	86	91	15.16	82	90	14.45	79	88	13.93	76	87	13.40	73	86	12.87	69	84	12.16
98	18.67	96	97	17.92	93	96	17.36	89	94	16.62	86	93	16.06	83	92	15.50	79	90	14.75	76	89	14.19	73	88	13.63	70	87	13.07
100	19.77	96	99	18.98	93	98	18.38	89	96	17.59	86	95	17.00	83	94	16.41	80	93	15.81	77	91	15.22	73	90	14.43	70	89	13.84
104	22.13	97	103	21.46	93	102	20.58	90	100	19.91	87	99	19.25	83	98	18.36	80	97	17.70	77	95	17.04	74	94	16.37	71	93	15.71
108	24.72	97	107	23.98	93	106	22.99	90	104	22.25	87	103	21.51	84	102	20.77	81	101	20.02	78	100	19.28	75	98	18.54	72	97	17.80
112	27.88	97	111	27.02	94	110	26.19	90	109	25.07	87	107	24.24	84	106	23.40	81	105	22.57	79	104	21.60	76	103	20.90	73	101	20.34
116	30.10	97	115	29.20	94	114	28.29	91	113	27.39	88	111	27.21	85	110	26.31	82	109	25.40	79	108	24.50	76	107	23.60	74	105	22.99
120	34.80	97	119	33.76	94	118	32.71	91	117	31.67	88	115	30.62	85	114	29.58	82	113	28.88	80	112	27.84	77	111	26.78	74	110	25.71

Relative Humidity, Dew Points and Grains of Moisture per Cubic Foot for various Dry and Wet Bulb Temperatures of the Sling Psychrometer—Barometric Pressure, 30 Inches

Dry Bulb Temp.	WET BULB DEPRESSION																											
	10			11			12			13			14			15			16			17			18		
	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins
32	2	−42	0.04																								
34	8	−17	0.18	0																							
36	13	−6	0.32	5	−25	0.12																					
38	17	1	0.45	10	−10	0.27	2	−36	0.05																		
40	22	7	0.63	15	−1	0.43	7	−14	0.20	0																	
42	26	12	0.80	19	6	0.58	12	−3	0.37	5	−18	0.15															
44	30	16	0.99	23	11	0.76	16	4	0.53	10	−5	0.33	4	−24	0.13												
46	32	20	1.13	26	15	0.92	20	10	0.71	14	3	0.50	8	−7	0.28	2	−30	0.07									
48	35	23	1.33	29	19	1.11	23	14	0.88	18	9	0.68	12	1	0.46	7	−10	0.27	1	−41	0.04						
50	38	26	1.55	32	22	1.30	27	18	1.10	21	13	0.86	16	8	0.65	10	0	0.41	5	−13	0.20	0					
52	40	29	1.75	35	26	1.53	29	22	1.27	24	18	1.05	19	13	0.83	14	7	0.61	9	−2	0.39	4	−17	0.18			
54	42	32	1.97	37	29	1.73	32	25	1.49	27	22	1.27	22	18	1.03	17	12	0.80	12	6	0.56	8	−4	0.38	3	−20	0.14
56	44	34	2.21	39	32	1.96	34	29	1.71	30	25	1.51	25	22	1.25	20	17	1.00	16	12	0.80	11	5	0.55	7	−5	0.35
58	46	37	2.47	41	35	2.20	37	32	1.99	32	29	1.72	27	25	1.45	23	21	1.24	18	17	0.97	14	11	0.75	10	4	0.54
59	47	39	2.61	42	36	2.33	38	33	2.11	33	30	1.83	29	27	1.61	24	23	1.33	20	19	1.11	16	14	0.89	11	8	0.61
60	48	40	2 76	43	38	2.47	39	35	2.25	34	32	1.95	30	29	1.72	26	25	1.50	21	21	1.21	17	17	0.98	13	11	0.75
61	49	42	2 97	44	39	2.61	40	36	2.38	35	33	2.08	31	30	1.84	27	27	1.60	22	23	1.31	18	19	1.07	14	14	0.83
62	50	43	3.07	45	40	2.76	41	38	2.52	36	35	2.21	32	32	1.97	28	29	1.72	24	25	1.47	20	21	1.23	16	16	0.98
63	50	44	3.28	46	42	2 92	42	39	2.67	37	36	2.34	33	34	2.17	29	30	1.84	25	27	1.59	21	23	1.33	17	19	1.08
64	51	46	3.35	47	43	3.09	43	41	2.82	38	38	2.49	34	35	2.23	30	32	1.97	26	29	1.71	22	25	1.44	18	21	1.18
65	52	47	3.53	48	45	3.26	44	42	2.98	39	40	2.65	35	37	2.37	31	34	2.10	27	31	1.83	24	27	1.63	20	24	1.36
66	53	48	3.71	48	46	3.36	44	44	3.08	40	41	2.80	36	38	2.52	32	35	2.24	29	32	2.03	25	29	1.75	21	26	1.47
67	53	49	3.84	49	47	3.55	45	45	3.19	41	43	2.97	37	40	2.68	33	37	2.39	30	34	2.17	26	31	1.88	22	28	1.59
68	54	51	4.04	50	49	3.74	46	46	3.44	42	44	3.14	38	42	2.84	34	39	2.54	31	36	2.32	27	33	2.00	23	29	1.72
69	55	52	4.25	51	50	3.94	47	48	3.63	43	45	3.32	39	43	3.01	35	40	2.70	32	37	2.47	28	34	2.16	24	31	1.85
70	55	53	4.39	51	51	4.07	48	49	3.83	44	47	3.51	40	44	3.19	36	42	2.87	33	39	2.63	29	36	2.31	25	33	2.00
71	56	54	4.62	52	52	4.29	48	50	3.96	45	48	3.71	41	46	3.38	37	43	3.05	33	41	2.72	30	38	2.47	27	35	2.23
72	57	56	4.86	53	54	4.51	49	52	4.17	45	50	3.83	42	47	3.57	38	45	3.23	34	42	2.89	31	40	2.64	28	37	2.38
73	57	57	5.01	53	55	4.65	50	53	4.39	46	51	4.04	42	49	3.69	39	46	3.43	35	44	3.07	32	41	2.81	29	38	2.55
74	58	58	5.26	54	56	4.90	50	54	4.53	47	52	4.26	43	50	3.90	39	48	3.54	36	45	3.26	33	43	2.99	29	40	2.63
75	58	59	5.43	54	57	5.05	51	55	4.77	47	54	4.40	44	51	4.12	40	49	3.74	37	47	3.46	34	44	3.18	30	42	2.81
76	59	60	5.70	55	59	5.31	51	57	4.92	48	55	4.64	44	53	4.25	41	51	3.96	38	48	3.67	34	46	3.28	31	43	2.99
77	59	62	5.88	56	60	5.58	52	58	5.18	48	56	4.78	45	54	4.48	42	52	4.18	39	50	3.89	35	48	3.49	32	45	3.19
78	60	63	6.17	56	61	5.76	53	59	5.45	49	57	5.04	46	55	4.73	43	53	4.42	39	51	4.01	36	49	3.70	33	46	3.39
79	60	64	6.36	57	62	6.04	53	60	5.62	50	59	5.30	46	57	4.88	43	55	4.56	40	53	4.24	37	50	3.92	34	48	3.60

Relative Humidity, Dew Points and Grains of Moisture per Cubic Foot for various Dry and Wet Bulb Temperatures of the Sling Psychrometer—Barometric Pressure, 30 Inches

Dry Bulb Temp.	WET BULB DEPRESSION 10			11			12			13			14			15			16			17			18		
	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins
80	61	65	6.67	57	63	6.23	54	62	5.90	50	60	5.47	47	58	5.14	44	56	4.81	41	54	4.48	38	52	4.16	35	50	3.83
81	61	66	6.88	58	65	6.54	55	63	6.20	51	61	5.75	48	59	5.41	45	57	5.07	42	55	4.74	39	53	4.40	36	51	4.06
82	61	67	7.09	58	66	6.74	55	64	6.39	51	62	5.93	48	60	5.58	45	59	5.23	42	57	4.88	39	55	4.53	36	52	4.19
83	62	69	7.43	59	67	7.07	56	65	6.71	52	64	6.23	49	62	5.87	46	60	5.52	43	58	5.01	40	56	4.65	37	54	4.44
84	62	70	7.66	59	68	7.29	56	66	6.92	52	65	6.43	49	63	6.06	46	61	5.68	43	59	5.31	40	57	4.94	37	55	4.57
85	63	71	8.02	60	69	7.64	57	68	7.26	53	66	6.75	50	64	6.37	47	62	5.99	44	61	5.60	41	59	5.22	38	57	4.84
86	63	72	8.27	60	70	7.88	57	69	7.48	53	67	6.96	50	65	6.56	47	64	6.17	44	62	5.78	42	60	5.52	39	58	5.12
87	64	73	8.66	61	72	8.25	57	70	7.71	54	68	7.17	51	67	6.90	48	65	6.49	46	63	6.22	43	61	5.82	40	59	5.41
88	64	74	8.92	61	73	8.50	57	71	7.94	54	69	7.53	51	68	7.11	48	66	6.69	46	64	6.41	43	62	5.99	40	61	5.58
89	65	75	9.33	61	74	8.76	58	72	8.33	55	71	7.90	52	69	7.47	49	67	7.04	47	66	6.75	44	64	6.32	41	62	5.89
90	65	76	9.61	61	75	9.09	58	73	8.58	55	72	8.13	52	70	7.69	49	69	7.25	47	67	6.95	44	65	6.51	41	63	6.06
92	65	79	10.20	62	77	9.73	59	76	9.26	56	74	8.79	53	73	8.32	50	71	7.84	48	69	7.53	45	68	7.06	42	66	6.59
94	66	81	10.98	63	79	10.48	60	78	9.98	57	76	9.48	54	75	8.98	51	73	8.48	49	72	8.15	46	70	7.65	43	68	7.15
96	66	83	11.63	63	82	11.11	61	80	10.75	58	79	10.22	55	77	9.69	52	76	9.17	50	74	8.81	47	72	8.28	44	71	7.76
98	67	85	12.51	64	84	11.95	61	82	11.39	58	81	10.83	56	79	10.46	53	78	9.90	50	76	9.34	48	75	8.96	45	73	8.40
100	68	87	13.44	65	86	12.85	62	85	12.26	59	83	11.66	56	82	11.07	54	80	10.67	51	79	10.08	49	77	9.69	46	76	9.09
104	69	92	15.27	66	90	14.60	63	89	13.94	60	88	13.28	58	86	12.83	55	85	12.17	53	83	11.73	50	82	11.06	48	80	10.62
108	70	96	17.30	67	95	16.56	64	93	15.82	62	92	15.33	59	91	14.59	57	89	14.09	54	88	13.35	52	86	12.85	49	85	12.11
112	70	100	19.50	68	99	18.94	65	98	18.11	63	96	17.55	60	95	16.72	58	94	16.16	55	92	15.39	53	91	14.84	51	90	14.28
116	71	104	22.05	69	103	21.45	66	102	20.55	64	101	19.95	61	99	19.05	59	98	18.45	57	97	17.85	54	95	16.87	52	94	16.21
120	72	108	25.01	69	107	23.95	67	106	23.24	65	105	22.40	62	104	21.46	60	102	20.75	58	101	20.07	55	100	19.05	53	98	18.37

Relative Humidity, Dew Points and Grains of Moisture per Cubic Foot for various Dry and Wet Bulb Temperatures of the Sling Psychrometer—Barometric Pressure, 30 Inches

Dry Bulb Temp.	WET BULB DEPRESSION																											
	19			20			21			22			23			24			25			26			27		
	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins
56	2	−25	0.10																								
58	6	−6	0.32	1	−30	0.05																					
60	9	4	0.52	5	−8	0.29	1	−36	0.06																		
62	12	11	0.74	8	3	0.49	4	−9	0.25	1	−45	0.06															
64	15	17	0.98	11	11	0.72	7	3	0.46	4	−10	0.26	0														
66	17	22	1.19	14	17	0.98	10	11	0.70	7	2	0.49	3	−11	0.21	0											
68	20	26	1.50	16	22	1.20	13	17	0.97	10	11	0.75	6	2	0.45	3	−11	0.22									
70	22	30	1.76	19	26	1.52	15	22	1.20	12	17	0.96	9	11	0.72	6	2	0.48	3	−11	0.24						
72	24	33	2.04	21	30	1.79	18	26	1.53	15	22	1.28	12	17	1.02	9	11	0.77	6	3	0.51	3	−11	0.26			
74	26	37	2.36	23	34	2.09	20	30	1.81	17	27	1.54	14	23	1.27	11	18	1.00	8	12	0.73	5	3	0.45	3	−10	0.27
75	27	39	2.53	24	36	2.25	21	32	1.96	18	29	1.68	15	25	1.40	12	21	1.12	9	15	0.84	7	8	0.66	4	−2	0.37
76	28	41	2.70	25	38	2.41	22	34	2.12	19	31	1.84	16	27	1.55	13	23	1.26	11	18	1.06	8	12	0.77	5	4	0.48
77	29	42	2.89	26	39	2.59	23	36	2.29	20	33	1.99	17	29	1.69	14	26	1.39	12	21	1.20	9	16	0.90	6	9	0.60
78	30	44	3.08	27	41	2.78	24	38	2.47	21	35	2.16	18	31	1.85	16	28	1.64	13	24	1.34	10	19	1.03	8	13	0.82
79	31	46	3.29	28	43	2.97	25	40	2.65	22	37	2.33	19	34	2.01	17	30	1.80	14	26	1.48	11	22	1.17	9	16	0.95
80	32	47	3.50	29	44	3.17	26	42	2.74	23	39	2.52	20	36	2.19	18	32	1.97	15	28	1.64	12	24	1.31	10	20	1.09
81	33	49	3.72	30	46	3.38	27	43	3.04	24	41	2.71	21	38	2.37	19	34	2.14	16	31	1.80	13	27	1.47	11	22	1.24
82	33	50	3.84	30	48	3.49	28	45	3.26	25	42	2.91	22	39	2.56	20	36	2.33	17	33	1.98	14	29	1.63	12	25	1.40
83	34	52	4.08	31	49	3.72	29	47	3.48	26	44	3.12	23	41	2.76	21	38	2.52	18	35	2.16	15	31	1.80	13	27	1.56
84	35	53	4.33	32	51	3.95	29	48	3.58	26	46	3.31	24	43	2.97	21	40	2.59	19	37	2.35	16	34	1.98	14	30	1.73
85	36	54	4.59	33	52	4.20	30	50	3.82	27	48	3.44	25	45	3.18	22	42	2.80	20	39	2.55	17	36	2.17	15	32	1.91
86	36	56	4.73	33	54	4.33	31	52	4.07	28	49	3.68	26	47	3.41	23	44	3.02	21	41	2.76	18	38	2.36	16	34	2.10
87	37	57	5.00	34	55	4.60	32	53	4.33	29	51	3.92	26	48	3.52	24	46	3.25	22	43	2.98	19	40	2.57	17	36	2.30
88	37	59	5.16	35	57	4.88	32	55	4.46	30	52	4.18	27	50	3.76	25	47	3.48	22	45	3.07	20	42	2.79	18	38	2.51
89	38	60	5.46	36	58	5.17	33	56	4.74	31	54	4.45	28	51	4.02	26	49	3.73	23	46	3.30	21	44	3.02	19	41	2.73
90	39	61	5.77	36	59	5.33	34	57	5.03	31	55	4.59	29	53	4.29	26	51	3.85	24	48	3.55	22	45	3.25	19	43	2.81
92	40	64	6.28	37	62	5.81	35	60	5.49	32	58	5.02	30	56	4.71	28	54	4.39	25	51	3.92	23	49	3.61	21	46	3.30
94	41	67	6.82	38	65	6.32	36	63	5.99	33	61	5.49	31	59	5.16	29	57	4.82	27	55	4.49	24	52	3.99	22	50	3.66
96	42	69	7.40	39	67	6.87	37	66	6.52	35	64	6.17	32	62	5.64	30	60	5.29	28	58	4.94	26	55	4.58	24	53	4.23
98	43	72	8.03	40	70	7.47	38	68	7.10	36	66	6.72	34	64	6.35	32	63	5.98	29	61	5.41	27	58	5.04	25	56	4.67
100	44	74	8.70	41	72	8.10	39	71	7.71	37	69	7.31	35	67	6.92	33	65	6.52	30	63	5.93	28	61	5.54	26	59	5.14
104	46	79	10.18	43	77	9.51	41	76	9.07	39	74	8.63	37	72	8.19	35	71	7.75	33	69	7.30	31	67	6.86	29	65	6.42
108	47	84	11.62	45	82	11.12	43	81	10.63	41	79	10.14	39	77	9.64	37	76	9.15	35	74	8.65	33	72	8.16	31	71	7.66
112	49	88	13.70	47	87	13.12	44	85	12.26	42	84	11.68	40	82	11.10	38	81	10.54	36	79	9.98	35	78	9.42	33	76	8.86
116	50	93	15.62	48	91	14.98	46	90	14.33	44	88	13.69	42	87	13.04	40	86	12.40	38	84	11.78	36	83	11.16	34	81	10.56
120	51	97	17.69	49	96	16.96	47	94	16.28	45	93	15.60	43	92	14.92	41	90	14.24	40	89	13.90	38	87	13.20	36	86	12.49

Relative Humidity, Dew Points and Grains of Moisture per Cubic Foot for various Dry and Wet Bulb Temperatures of the Sling Psychrometer—Barometric Pressure, 30 Inches

Dry Bulb Temp.	WET BULB DEPRESSION 28			29			30			31			32			33			34			35		
	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins
75	1	−23	0.09																					
76	3	−10	0.29																					
77	4	−2	0.40	1	−21	0.10																		
78	5	5	0.51	3	−9	0.31																		
79	6	10	0.64	4	−1	0.42	1	−20	0.11															
80	7	13	0.77	5	6	0.55	3	−7	0.33															
81	9	17	1.02	6	10	0.68	4	0	0.45	1	−18	0.11												
82	10	20	1.16	7	14	0.81	5	7	0.58	2	−6	0.23	0											
83	11	23	1.32	8	18	0.96	6	11	0.72	3	2	0.36	2	−15	0.24									
84	12	26	1.48	9	21	1.11	7	15	0.87	5	8	0.62	3	−4	0.37	0								
85	13	28	1.66	10	24	1.27	8	19	1.02	6	12	0.77	4	3	0.51	2	−12	0.26						
86	14	31	1.84	11	27	1.44	9	22	1.18	7	16	0.92	5	9	0.66	3	−2	0.39	1	−27	0.13			
87	15	33	2.03	12	29	1.62	10	25	1.35	8	20	1.08	6	13	0.81	4	5	0.54	2	−10	0.27			
88	15	35	2.09	13	31	1.81	11	27	1.53	9	22	1.26	7	17	0.98	5	10	0.70	3	0	0.42	1	−22	0.14
89	16	37	2.30	14	34	2.01	12	30	1.72	10	26	1.44	8	21	1.15	6	15	0.86	4	6	0.57	2	−7	0.29
90	17	39	2.52	15	36	2.22	13	32	1.92	11	28	1.63	9	24	1.33	7	19	1.04	5	11	0.74	3	1	0.44
92	19	43	2.98	17	40	2.67	15	37	2.35	13	33	2.04	11	29	1.73	9	25	1.41	7	20	1.10	5	13	0.78
94	20	47	3.33	18	44	2.99	16	41	2.66	14	38	2.33	12	34	2.00	10	30	1.66	9	26	1.50	7	21	1.16
96	22	51	3.88	20	48	3.53	18	45	3.17	16	42	2.82	14	39	2.47	12	35	2.12	10	31	1.76	8	27	1.41
98	23	54	4.29	21	52	3.92	19	49	3.55	17	46	3.17	15	43	2.80	14	40	2.61	12	36	2.24	10	32	1.87
100	24	57	4.74	22	55	4.35	21	52	4.15	19	50	3.76	17	47	3.36	15	44	2.97	13	41	2.57	12	37	2.37
104	27	63	5.98	25	61	5.53	23	59	5.09	21	57	4.65	20	54	4.43	18	52	3.98	16	49	3.54	14	46	3.10
108	29	69	7.17	27	67	6.67	25	65	6.18	24	63	5.93	22	61	5.44	20	59	4.94	19	56	4.70	17	54	4.20
112	31	74	8.58	29	72	8.03	27	71	7.49	26	69	7.22	24	67	6.68	23	65	6.41	21	63	5.87	19	61	5.33
116	33	79	10.25	31	78	9.61	29	76	8.99	28	74	8.68	26	73	8.06	25	71	7.78	23	69	7.17	22	67	6.86
120	34	84	11.79	33	83	11.44	31	81	10.73	29	80	10.04	28	78	9.70	26	76	9.02	25	75	8.68	23	73	7.99

The Carrier Differential Thermostat

A device for automatically regulating the percentage of humidity regardless of the temperature.

It is positive and reliable.

It is the most accurate instrument invented.

It is constructed on correct scientific principles.

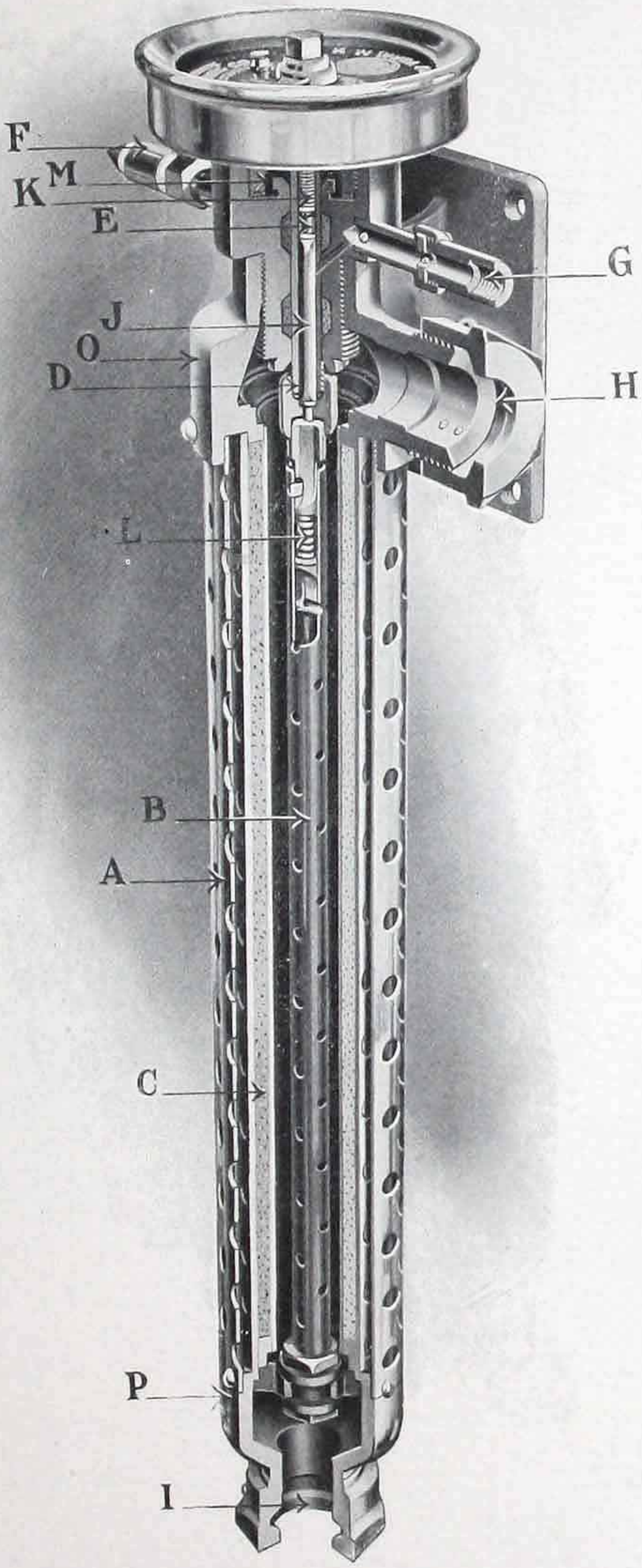
It is extremely simple in construction and operation.

It is guaranteed to regulate the percentage of humidity within two per cent.

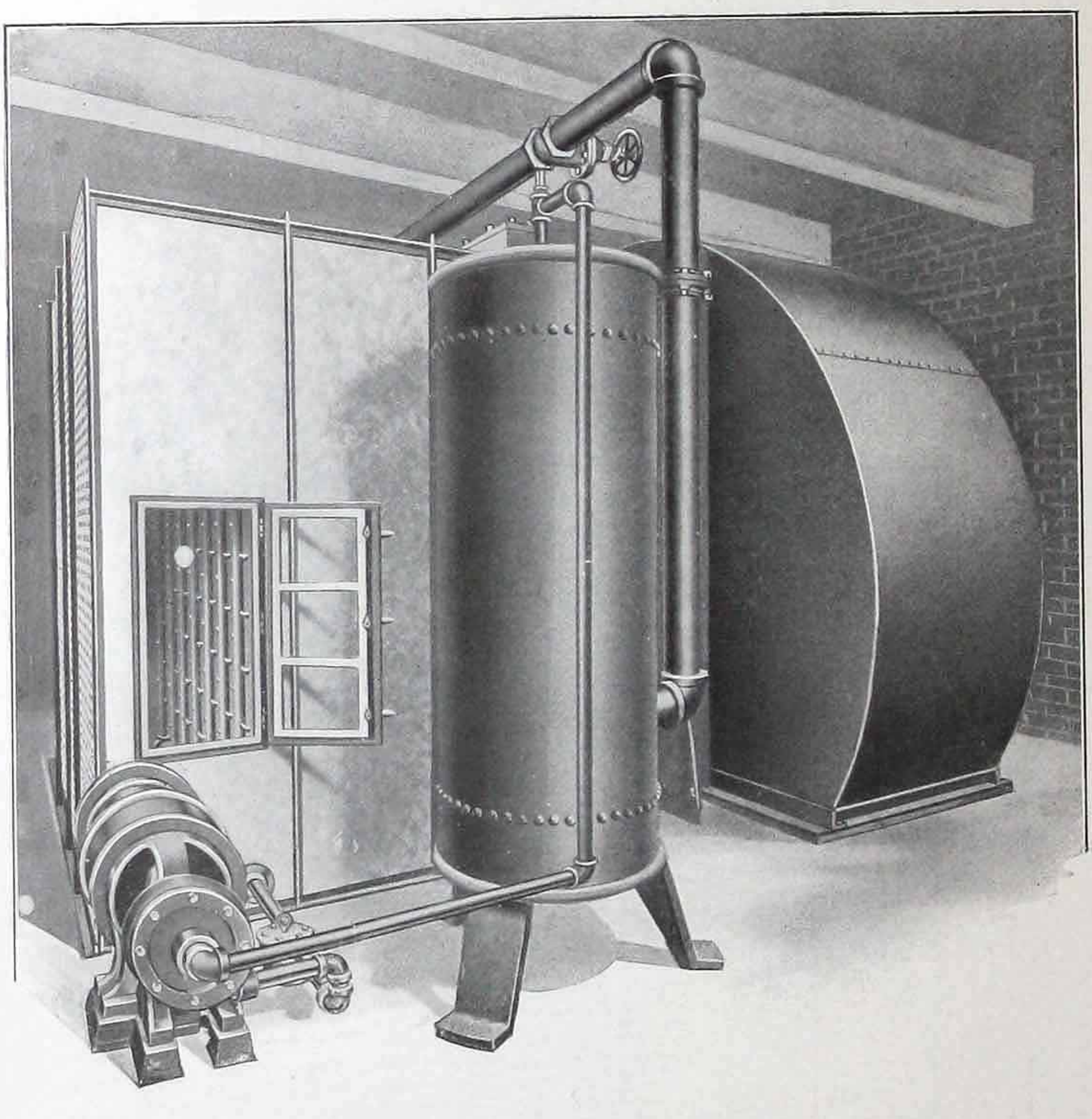
It is adapted for use either in connection with the Carrier System of Humidifying or with any other system.

It can be applied to old installations of any make as well as new systems.

Section No. 4 of Catalog describes it; if interested, write for a copy.



Differential Thermostat



One of four sets of Apparatus in the Luzerne County Court House
Wilkesbarre, Pa.

INDEX TO SECTION 1

Additional Publications

We have either in the press or under preparation the following catalogs:

Carrier System of Humidifying Applied to Textile Mills.

Carrier System and Devices for Humidity Control.

Carrier Air Washers and Humidifiers Applied to Public and Office Buildings.

Carrier System of Dehumidifying.

Carrier Humidity Indicating and Recording Devices.

Section C

Carrier Air Washers *and* Humidifiers Applied to Public Office and Industrial Buildings

Patented in the United States
Canada and Foreign Countries

Carrier Air Conditioning Company
of America
39 Cortlandt Street, New York, N. Y.

Press of
ROBERT L.
STILLSON
COMPANY
NY 122-126
CENTRE ST
NEW YORK

Application of Carrier Air Washers and Humidifiers

The science of heating has and is receiving a great deal of study from engineers, and as a result of the united efforts of those who are working for the betterment of their profession, our heating plants are becoming better designed, better proportioned to the work to be accomplished, and far more efficient.

Ventilation and Cleanliness of our buildings and the necessity of pure air, about which we read so much, but of which in practice we see so little, are also receiving a portion of the attention they deserve, and gradually the general public is becoming educated to the fact that ventilation is not a luxury, but a hygienic and economical necessity. Slowly and surely those who are studying the subject are also becoming convinced, that while ventilation is a necessity, the proper quality, as well as quantity of air should be furnished. That it is not sufficient to provide 20, 30 or 50 cubic feet of air per minute to each occupant of the room, but that this air must be properly washed or otherwise cleaned and purified in order to give even approximate ideal results.

A New Study: While there have been volumes written regarding heating and ventilating, and these have received the attention of some of our most eminent mechanical engineers, nearly or quite all until very recently have overlooked a subject almost as important and closely dependent upon these two—"Humidity".

The foremost and progressive engineers now, however, are giving the subject much attention and study, with the result that the installation of air washers and humidifiers is increasing very rapidly each year.

Necessity for Clean Air: In our cities the amount of solid matter carried in the air is enormous. The greater

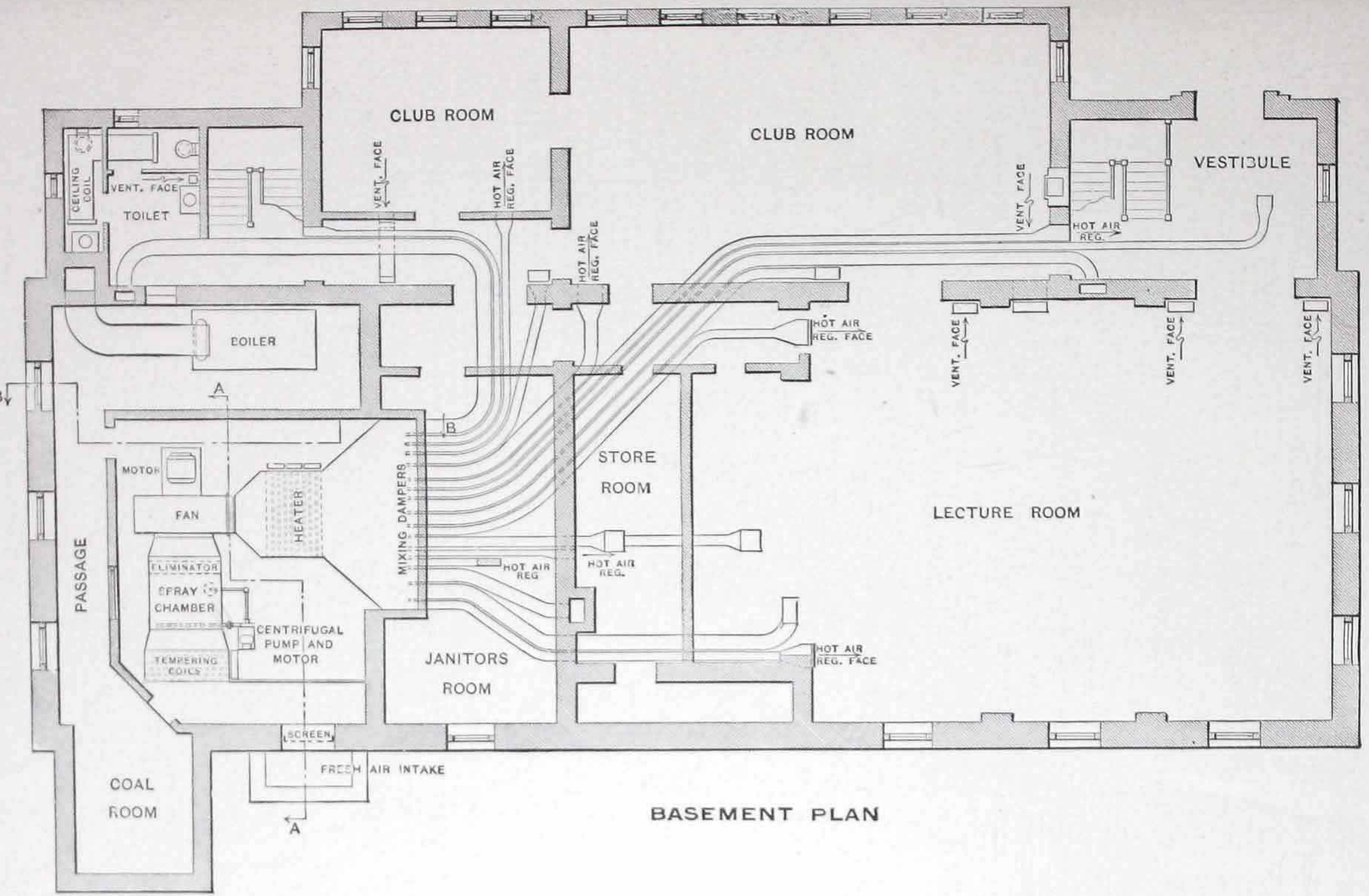
part of this consists of soot or unconsumed carbon from soft coal burning furnaces. In addition to this, all manner of impurities from the surface of the streets and sidewalks are kept in circulation by air currents. Dust and dirt brought into the building are usually evident on the walls and ceiling in the vicinity of a fresh air register or by the dust deposited on the furniture. Each year thousands of dollars' worth of fine goods are ruined on the shelves of stores by this means.

Location of Air Supply: These air currents carry filth and disease germs into our dwellings, schools, hospitals, offices and stores. How important it is, then, that the fresh air supply for the heating system should be above suspicion. But how can we arrive at this except by an air shaft extending to the roof? True, we avoid the street currents, but are even more subject to the black soot which defaces the walls and settles thickly on furniture and hangings. Successful as the elevated air shaft may be so far as concerns avoidance of disease germs and filth, the *expense* is almost prohibitive. The higher the building, the larger the air shaft necessary to convey the supply and the longer it must be. *Floor space* is a more valuable item even than the cost of the shaft, and the modern office or bank building cannot afford to sacrifice it.

In the great majority of cases the location for the fresh air inlet at the basement level, either through basement windows or through the sidewalk openings, is most *convenient* and *inexpensive*, but without some sure means of purifying it the most thoughtless owner would not consider delivering into his building air *loaded* with the scum of the street.

Early Cleaning: The first air washers used consisted of cheesecloth screens on wooden frames, which were made removable so as to be replaced when clogged with dirt. These have the advantage of being inexpensive, but on account of the friction imposed by the fabric, the area required is very large, necessitating a low velocity and consequently large amount of space occupied. The screens clog up quickly and cut down the air supply unless frequently

Barr Branch Library, St. Louis, Mo.



BASEMENT PLAN

changed. The act of replacing shakes loose some of the dust, which of course finds its way into the building. The principal disadvantage, however, lies in the constant attention required and the disuse into which any non-automatic apparatus falls when left to the attention of a busy janitor.

Bags: Another form taken by the same idea was the use of long bags, open at the top, and through the meshes of which the fresh air found its way into the heating apparatus; this is subject to very much the same objections as the screens, and in either case, it will be noted, no provision is made for moistening the air.

Coke Filter: An improvement on the cheesecloth screens is a coke air washer, consisting of a wall of coke between two wire screens. A constant trickle of water tends to keep the surface of the screen clean, but the contact is not thorough, the moistening effect is very slight, and the coke screen has the same disadvantages as the cheesecloth filter, requiring frequent renewal and a large amount of space.

Endless Belt: Another form of air washer which was employed with good results for moistening and cleaning the air supply of heating systems: consisted of an endless belt or screen of burlap passing over rollers and dipping into a settling tank, which filled the meshes of the screen with moisture and at the same time washed off the accumulated dust. The results obtained were good, but the apparatus occupied considerable space and, for mechanical objections impossible to overcome, it required considerable attention to keep it in order. We cannot enumerate all the various devices, more or less ingenious, which have been tried.

Present Type: Constant observation brought the conclusion that sufficient contact to moisten and purify the air could be obtained only by direct exposure to water sprays; that in this way only could the solid matter be entirely removed. Our experiments, extending over a long term of years, have included various applications of sprays, types of nozzles, and disposition of contact surfaces.

Humidity: In schools and other public buildings, the humidity of the air is of more consequence than is usually supposed. The amount of moisture which air can hold at saturation per unit of volume increases very rapidly with the temperature as shown by the psychrometric chart on page 33. At 70° it will hold 8 grains of moisture per cu. ft. while at 32° it can hold but 2 grains per cu. ft., and at zero only 0.5 grain. Air normally has a humidity varying from 45 to 70% of saturation, while if much above or below these limits it becomes uncomfortable if not actually injurious to the health. Hence, air at 70° should contain from 3.5 to 5.5 grains per cu. ft., while at 0° it contains only about 0.3 grains and at 32° about 1.25 grains, so that in the usual systems of heating, with 32° outside, the humidity of the air when heated to 70° would be only 15.5%, or about one-half the humidity of the dryest climate known. It is this extreme dryness of the air in a heated room which produces many of the discomforts commonly noticed, but not fully explained, such as extreme thirst, a parched feeling in the nose and throat, lassitude and headache. The effect of this extreme dryness is undoubtedly very harmful to the mucous membrane in nose, throat and the lungs, and may be considered a contributing source of many throat and pulmonary diseases.

Ordinary Rooms Dryer Than a Desert: When heating to the ordinary room temperature of 70°, the relative humidities will be only 5% and 20% respectively, with corresponding moisture deficits of 3 grains to 4 grains per cu. ft. This creates an artificial climate, dryer than that of any desert.

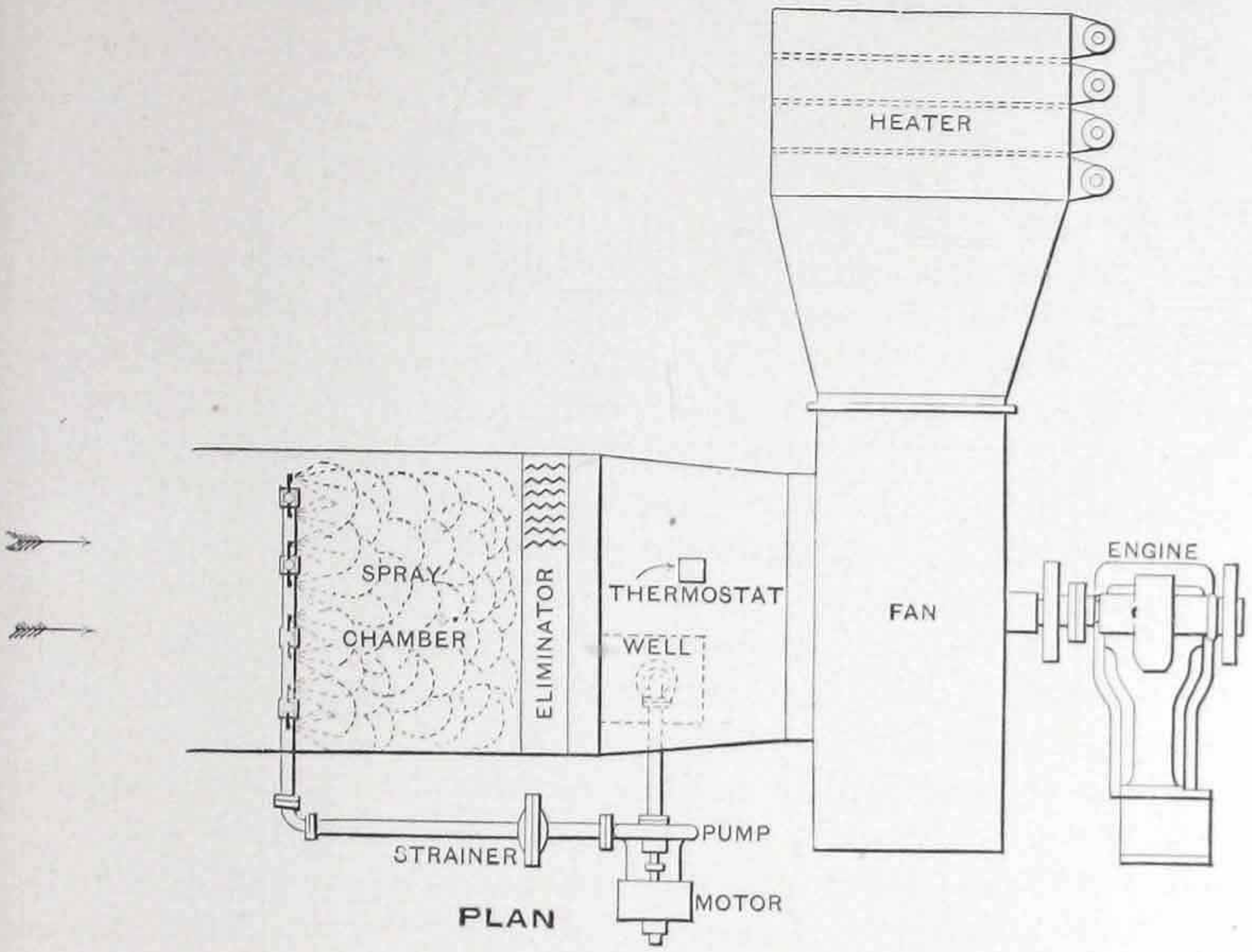
Outdoor Temperature	Per Cent. Humidity (assumed)	Per Cent. Humidity of same air when heated to 70°
0°	50	3
	80	5
15°	50	$6\frac{1}{4}$
	80	10
30°	50	$12\frac{1}{4}$
	80	$19\frac{1}{2}$
45°	50	$21\frac{1}{4}$
	80	34

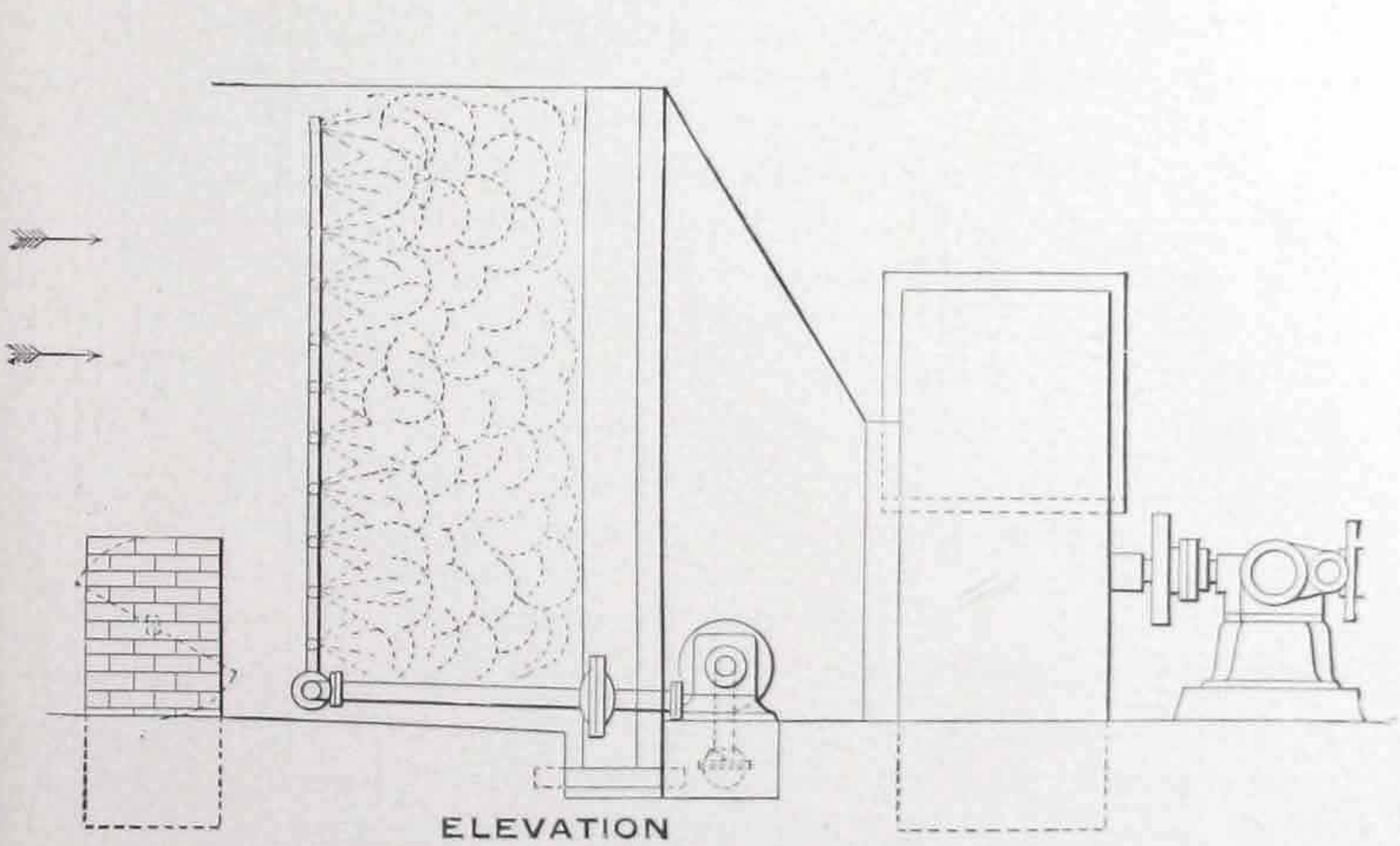
Hygienic Effects: From a hygienic standpoint, the relative humidity affects the mucous membrane of the nose, throat and lungs. Dry air readily absorbs moisture from the skin, drying and cracking the delicate tissue, and frequently causing throat irritation and consequent coughing. The injurious effect on the mucous membrane is especially aggravated by a wide indoor variation in humidity. In fact, the theory has been advanced that a copious supply of fresh air at a constant temperature and a fixed humidity in a sanitarium, would do much for the cure of lung, throat and nasal diseases, as much for instance as the comparatively fixed weather condition in Arizona.

An Interesting Paper: This subject was effectively treated in a paper by Henry Mitchel Smith, M. D., read before the Brooklyn Medical Society, May 15th, 1903; speaking of the need of some method for controlling humidity, he says: "This is a factor that has been overlooked, and in this omission lies the anomaly of modern heating. So long as we continue to neglect the indoor relative humidity we shall continue to live in the unhygienic surroundings created by any method of heating that is not supplied with means for properly moistening the air. To do this should be as much the purpose of a scientifically constructed heating system as to furnish sufficient heat."

"It is a fundamental principle in climatology that the relative humidity of any location is of the greatest importance, and yet in regulating the 'climate' of our homes in winter this factor is entirely overlooked. It is startling to hear that the average heated room is as dry as a desert, that this dryness forces us to heat it to a most unhygienic degree, that it causes a waste of fuel, and that diseases of the air passages are traceable to this source. Actual experiments show, however, that such statements are not exaggerated. References to the dryness of heated rooms have, as a rule, been so indefinite that they have failed to carry due weight, and *the importance of the subject has not been fully appreciated.*"

"The overheating of our houses has been accepted as a prominent cause of catarrh, but I am confident that the low relative humidity, and consequently the large saturation deficit of the aqueous vapor in the atmosphere of our rooms





Carrier Air Washer and Humidifier connected to Heating System

in winter, is much more important than is the overheating in itself, and it may be doubted whether the so-called damp climate of the seacoast or the shores of large inland lakes is in itself so responsible for the above diseases, as has been generally supposed."

Relation to Heating: To understand more thoroughly the relation of humidity to heating, it is necessary to know that the temperature felt by the body, or the *sensible temperature*, as it is called, corresponds to the temperature of the wet bulb thermometer; hence, the dryer the air the greater is the difference between the actual and sensible temperatures. Dry air heated much above the normal will still be chilly, slight drafts are very noticeable and colds are easily contracted.

The excessive evaporation from the skin lowers the temperature of the body very rapidly, and as a result higher temperatures are required than would be necessary for comfort if the proper amount of humidity were present. On the other hand, if the percentage of humidity is excessive, the evaporation from the body is below normal, causing the slow evaporation from the body, with the result that the body heat is not radiated as speedily as is necessary for the comfort.

Importance of Regulating Humidity: From the above it is evident that the means for regulating the humidity should be considered side by side with proper ventilation in every school or other public building. The means provided for supplying and controlling the humidity in such buildings is fully explained in section 1. The effect of humidity is also quite marked in other ways, and deserves careful consideration from an economical standpoint.

Waste of Fuel: It may be very easily demonstrated that an indoor temperature of 65°, when the moisture content corresponds to a humidity of 50% to 60%, is not only more *livable*, but actually gives an impression of greater warmth than a room with humidity at 30%, but heated to 70° or 75°. It is evident that we are uniformly maintaining a much higher temperature than would be necessary if proper humidity conditions were preserved. The saving effect in heating the air for ventilation to a lower tempera-

ture and the decrease in radiation losses at the lower room temperature will easily offset the cost of introducing the necessary moisture.

Control of Temperature: The *inconsistency* of maintaining an absolutely constant room temperature by an elaborate thermostatic system is evident when we consider that the sensible temperature, upon which our feelings of comfort are based, is allowed to vary over a wide range. Personal sensations of heat or cold, as we have just shown, depend by no means on temperature only. A sudden increase in humidity frequently gives us the sensation of oppressive heat which the thermometer does not confirm. The greater evaporative power of air at low humidity accounts for the sensation of cold, and the evaporation of moisture from the body is the principal cause of irritation of the tissues. No improvement in indoor atmospheric conditions can be expected until heating engineers and the public they serve realize that, with the ever-varying absolute humidity out of doors, no system of heating can be made satisfactory if the indoor relative humidity is disregarded. The most perfect automatic control of temperature will not fill the requirement, for a constant temperature is constant in its effects only if *accompanied* by a constant relative humidity.

The Problem: To furnish an air supply which is clean, pure, humidified and properly heated or cooled—these, briefly, are the considerations which must be borne in mind. In order that it may not appear too simple, it must be remembered that the space allowed for the apparatus is *limited*, and that every particle of air passing at a high velocity must be thoroughly purified and *moistened* in the instant elapsing between entering and leaving the humidifying chamber. Not only this, but every particle of free moisture must be *separated* and removed from the air before passing further on. It is also essential that the proper temperature be maintained in the humidifying chamber to insure humidity control. These problems are all essentials, and we are prepared to state definitely that each and every condition laid down has been fully satisfied.

An Erroneous Idea of Weather Conditions: In summer it so happens that the hottest parts of the day, almost without exception, have comparatively a low relative humidity.

We often hear persons complaining of 85° or 90° temperature and 90% humidity; in fact, it is not unusual for writers upon the subject of humidity to make such reference. Such conditions never exist in our climate, as a careful survey of the climatic records will show.

The Actual Conditions: We often have 95%, or even 100% saturation early in the mornings, or on foggy days at temperatures in summer of 75° or below. As the day grows warmer it will be found that the relative humidity decreases. There is just as much water vapor in the atmosphere, but owing to the increased temperature the moisture holding capacity has increased. (See page 25 of the first section of this catalog.) The lower the relative humidity the greater is the difference between the wet and dry bulb temperatures. New York City, as compared to other localities, usually has a high percentage of humidity, being surrounded as it is by water, but whenever the temperature reaches 85° it will be found that the percentage of humidity is below 65%, and that on hot days the wet bulb thermometer registers about 15° below the dry bulb temperature. In dry climates the depression of the wet bulb is still greater.

Cooling by Evaporation: As explained on page 30, when air is brought in contact with a minutely divided or atomized spray water at ordinary temperatures, a portion of the water is evaporated, thus lowering the temperature of the air. The amount of cooling that is procured bears a direct relation to difference between the wet and dry bulb temperatures of the entering air.

A Carrier Air Washer and Humidifier, installed in one of the largest New York hotels during hot days, was able to deliver air to one of their dining-rooms at an average of 13° below the outside temperature, thereby lowering the temperature of the room 10° lower than when the Air Washer and Humidifier was not in use. These results were obtained when using the same water over and over and without

causing a relative humidity in the room that was at all objectionable.

The cooling effect thus produced at a very low cost is of great importance to hotels, theaters, banks, stores and office buildings, not only because of the increased cleanliness and the more efficient work procured from the help due to the cooler and more invigorating atmosphere, but as an inducement to customers to visit those shops where they may be comfortable.

Cooling by Refrigerating Machines: Where ideal results are desired for summer a few buildings in the past have been provided with ice machines for cooling and dehumidifying.

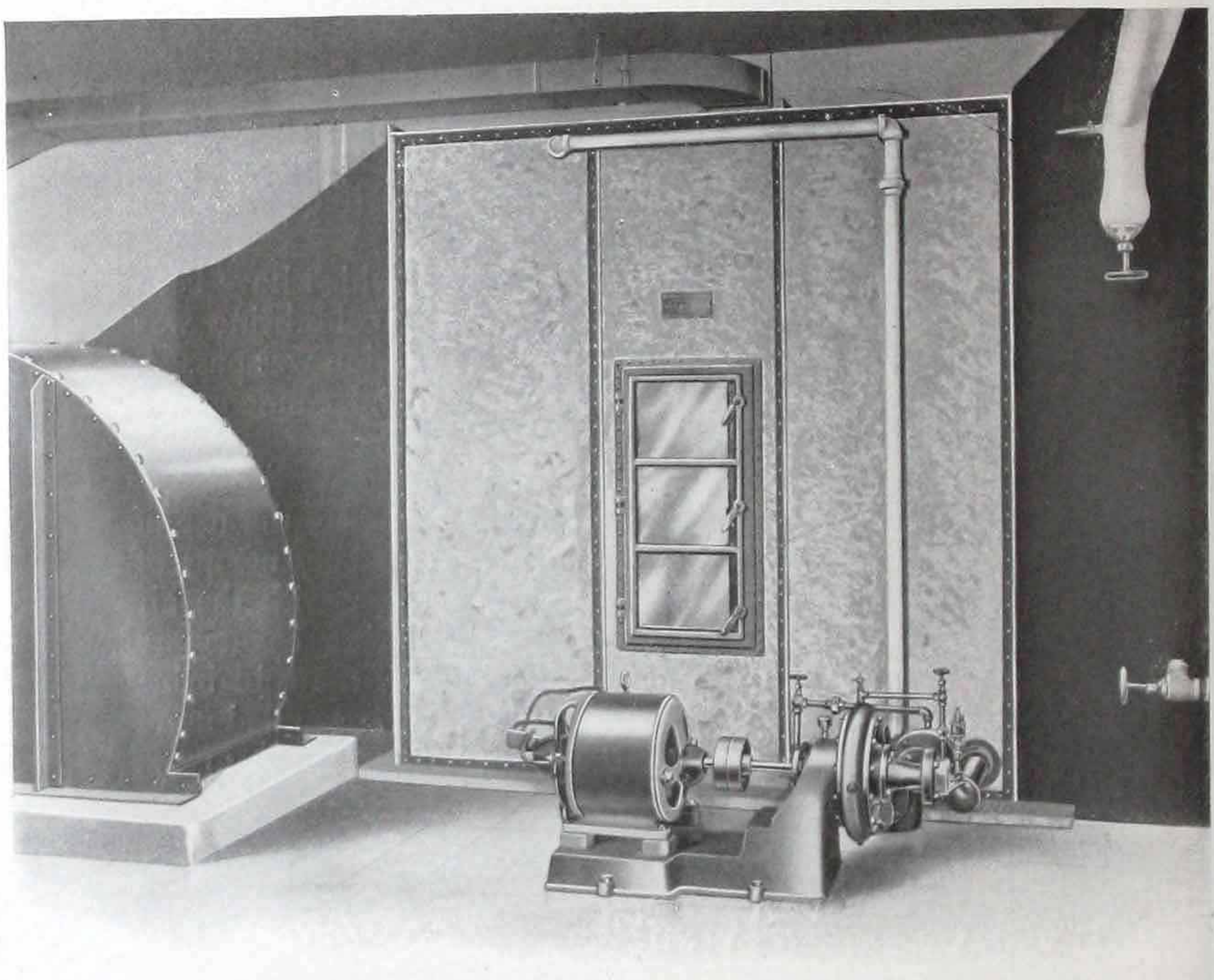
Those installations, generally speaking, which have been successful have used coils through which cold brine was circulated and over which the air for ventilation was passed.

The cold pipe surface cooled the air and condensed a portion of the moisture.

Carrier System of Dehumidifying: By the use of the Carrier System the water which is cooled by means of the ice machines is brought in direct contact with the air to be cooled. The cooling and dehumidifying effects are identical with the results obtained by use of the cold brine coils except that the Carrier System can be controlled more easily. The advantages of the Carrier System are many; namely:

1st. The saving of power and size of the ice machines.
2d. The saving in first cost.
3d. The saving in space.
4th. The saving in attendance.
5th. A more efficient means of heat transfer, due to the intimate contact of the cold water and the air.
6th. The elimination of the trouble of ice or frost being deposited on the pipes, which has to be occasionally thawed off.

Well Water: In many localities an abundance of well water is available at temperatures ranging from 54° to 60° F. In such cases all results and benefits derived from



Carrier Air Washer and Humidifier in the Oliver H. Blair Building, Philadelphia, Pa.

an ice machine are procurable, except where unusually low temperatures and humidities are required. With the water entering at 54° the air can be cooled to 60° or lower, depending upon the relative amounts of air and water used.

Successful installation of the Carrier System, using both refrigerated water and cold well water, are in operation.

Public Buildings and Offices: The Carrier Air Washer and Humidifier is adapted for use in all public buildings where health, comfort and cleanliness are factors considered. No heating and ventilating system is perfect or hygienic without it. In winter it relieves the oppressive and unhealthful dryness of the heated buildings by imparting to the air a natural and well regulated humidity—a feature particularly valuable in schools and offices. In summer it combines its functions as an effective medium for ventilation and purification of the air supplied with that of cooling. The reduction of temperature effected depends on the temperatures of air and water respectively; the average cooling effect is about 10°, and the conditions governing this are covered more fully in the foregoing paragraphs.

Libraries and Banks: In libraries, where cleanliness of the air is of great importance, the system is invaluable, as it removes all traces of dust and soot, and a uniform relative humidity is very necessary for the preservation of books and records.

An eminent New York engineer, who was called upon to investigate the conditions in one of the large libraries in St. Louis, discovered that the lack of a proper percentage of humidity was ruining the leather bindings of the books within three years. Banks find it a valuable adjunct to the heating and ventilation. The La Crosse, Wisconsin, National Bank have the following to say in regard to the Carrier Air Washer:

"I am glad to state that the air washer which you installed in our new building is working very satisfactorily and we believe it to be as good as anything of the kind on the market. We do not hesitate to recommend it without reservation to anyone looking for an air purifier."

Theaters and Churches: Any crowded hall of audience is in particular need of ventilation at all times and

of cooling in summer. Large quantities of air are introduced through the various openings located about the auditorium and galleries where necessary to give a thorough distribution. To cool such a large volume sufficiently to produce a perceptible difference of temperature requires an abstraction of an immense amount of heat. To produce this cooling effect by passing the air over brine coils would require a large additional space, and on account of the inefficiency of the cooling surface, an expense for refrigerating apparatus nearly equal to the entire heating plant. Systems like this have been installed, but the cost has made such installations notable exceptions. An atomized spray of water offers an enormous cooling surface as compared with either of the foregoing. The innumerable particles in intimate contact bring the temperature of the air nearly to that of the water, and this system offers by far the most practical and inexpensive means of cooling on a large scale wherever such cooling is combined with ventilation.

Hotels and Department Stores: Any merchant readily appreciates the great saving to his goods if dust and dirt could be eliminated from his store. A proper installation of a Carrier Air Washer and Humidifier will entirely eliminate all dust brought in by the ventilating apparatus, and if the supply is ample all windows and doors can be kept closed, thus preventing any dirt from being blown in from the streets. The cooling of the building, however, is of the greatest importance, as the evaporation will keep the building at a cool and comfortable temperature.

A comfortable and clean establishment is a valuable asset to any store, hotel, or restaurant, and the proper humidity in a furniture store is very important to prevent the swelling or drying out of the furniture.

Mr. W. C. Grobheiser of the Manufacturers' Building Co., Grand Rapids, Mich., wrote us as follows:

"In regard to the Air-Washer your Company installed for us in our exhibition building, I am pleased to say it has apparently given the best of satisfaction. Our Company, as you know, is composed entirely of manufacturers, who naturally are conversant with mechanical apparatus and who are quick to note defects in anything in the nature of

machinery or appliances, or in the results obtained therefrom. I expected a criticism on this account, if there was any opportunity for it, as not all the members of our Company were thoroughly satisfied that it was policy to install an air-washer. But I am quite certain that in this respect they have been fully satisfied with the result obtained.

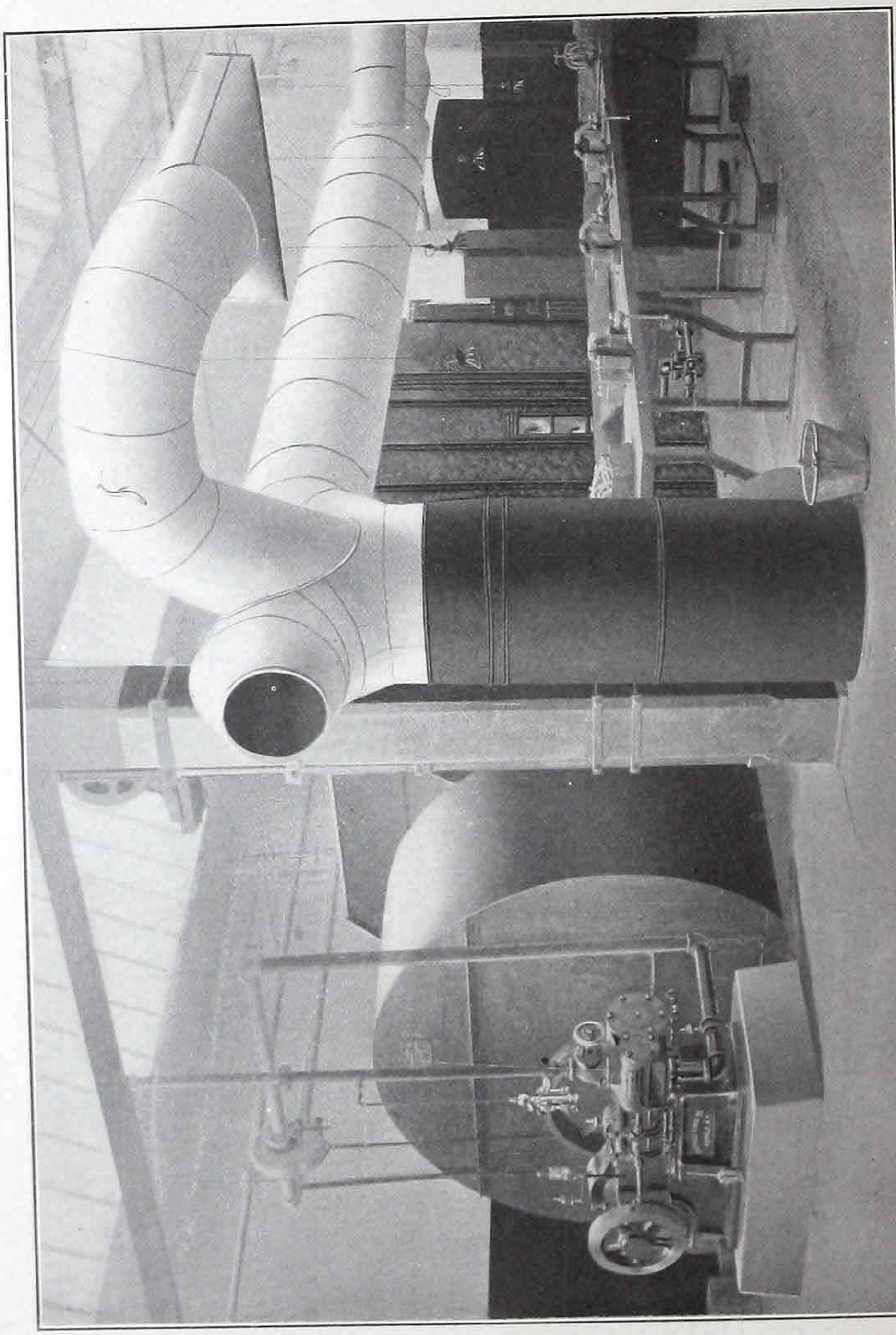
"We note one special feature in your air-washer that we think commendable, namely, that there is nothing in the nature of cloth screens or coke chambers to be replaced and cleaned, and as long as we have used your apparatus nothing has been required except to turn the current on the water pump.

"You may remember that in giving you our contract we made some very severe restrictions in regard to your successfully washing the air distribute throughout the building and leaving it dry enough to not affect the drawer work in our furniture exhibits. Under ordinary conditions a damp day will swell the drawers so that they cannot be opened, and we feared this result in the use of your washer, and as the entire seven floors of our building are filled with furniture exhibits, almost every sample of which is handled daily, it is quite certain had the washer failed in its operation we should have heard from our many exhibitors, but after carefully inquiring among them I fail to find a single instance where there was a question in this respect.

"As you are aware we are adding to the capacity of our building and making changes in the heating system, and we may consult you in reference to changes we are making as we do not wish to make such important changes without consulting you.

"And if the system works as satisfactorily after we get these changes made, we shall certainly be very pleased with it and thoroughly satisfied that all your claims have been substantiated."

Lithographing and Color Printing Plants: Aside from the increased cleanliness due to the use of the Carrier Air Washer and Humidifier, the question of an even and uniform humidity is of the greatest importance to those printing establishments where close register work is done. With a constant temperature and a constant relative humidity there will be no expansion or contraction of the stock,



Carrier System installed in the plant of the Warner Instrument Company, Beloit, Wis.

no wrinkling of the edges and no changes in the stones after the job is once started through the press.

The Schmidt Lithographing Company of San Francisco wrote our representative as follows:

"Referring to your recent request as to a statement from us whether we are perfectly satisfied with your Heating and Ventilating Plant which has been in a working condition for several months, we simply want to state that we consider this system one of the best investments we have ever made. By your arrangement of regulating the temperature and humidity throughout our plant, we have overcome all of the previous difficulties we have been having in the various branches of our business.

"We especially want to recommend your humidifying arrangement. Since we have installed your system we have entirely overcome the previous unavoidable wrinkling of our paper, and this alone is a big item in our business."

Industrial Plants: There are many plants where it is of the greatest importance to have all dirt, dust and other foreign matter removed from the air entering the building. This especially refers to writing and coated paper plants, watch factories, or where similarly fine and delicate work is performed. The Carrier Air Washer, by the elimination of dust falling on the product or work, makes it possible to produce a better output.

Mr. C. H. Warner, president of the Warner Instrument Company, wrote an inquirer as follows:

"This system was installed in Oct. 1907, and therefore has been in use for one year, giving us perfect satisfaction. The air washer removes all dust, soot, etc., from the air, including all insects, leaving the air perfectly sweet and clean as it enters the building. During the last summer we found that we could lower the temperature about six degrees by the use of the Air Washer, which made the building much more comfortable for our workmen."

Dust Collecting: In smelting works and reclaiming plants, small particles of precious metals are carried along with the furnace gases. From the buffing and polishing wheels of jewelry factories and silversmiths a great deal

of valuable metal is continually being lost. Settling chambers, dust collectors, operated by centrifugal force, and screen devices have been used with only partial success, due to the fact that the heavy rouge and lint are caught, but the larger part of the valuable metal is in very fine particles, which escape with the air.

The Carrier Air Washer removes and collects practically all this fine metal. In some plants the value of the metal collected in a few months is sufficient to pay the entire cost of the equipment.

One of our earliest installations was made in connection with smelting furnaces, where the saving has been enormous.

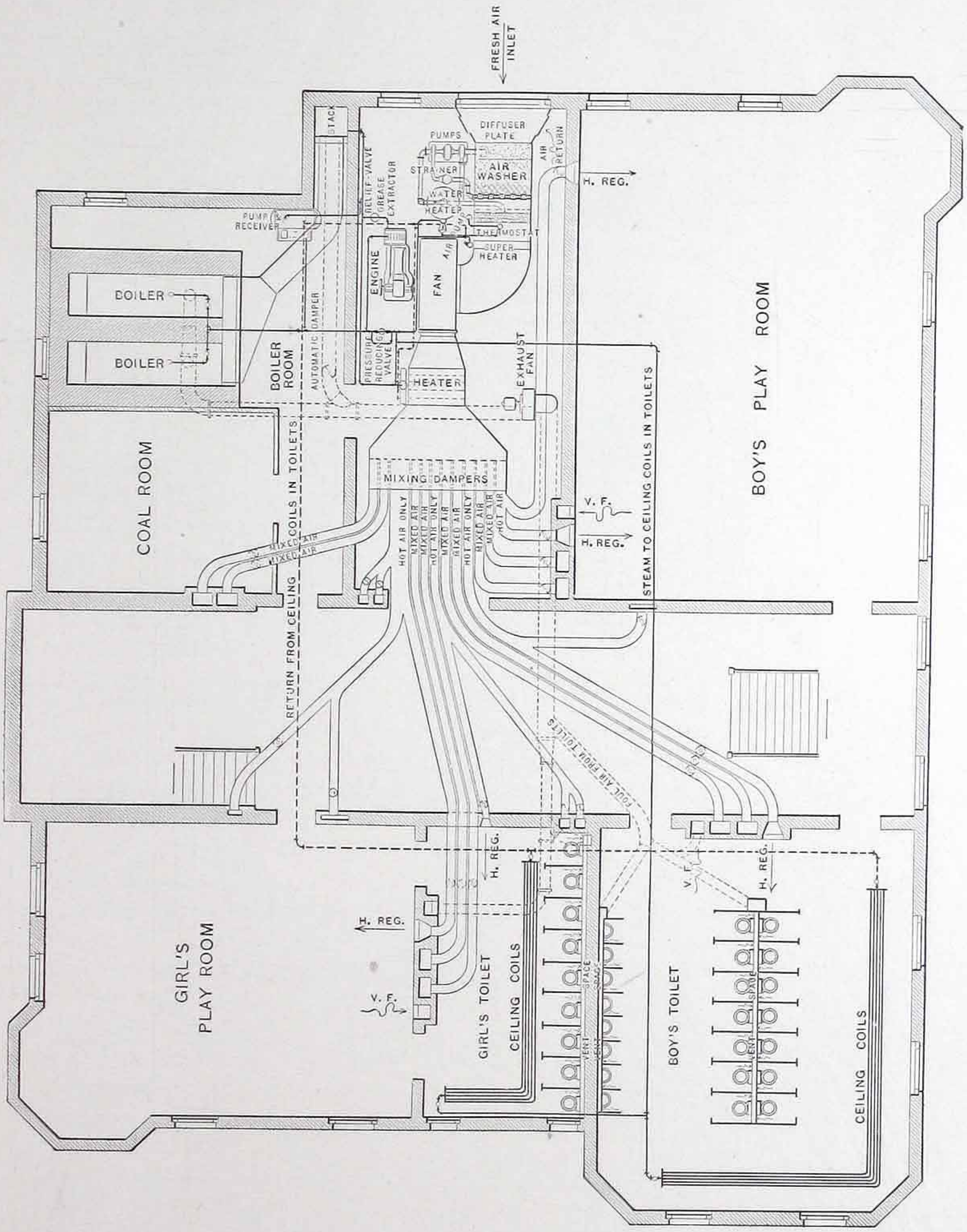
Drying and Humidifying: The drying of nearly all products of manufacture is accomplished by passing air over the product that has been heated to a high temperature, so its relative humidity is low. The capacity of absorbing moisture is even more dependent upon the relative humidity than upon the temperature, although both are the direct factors which determine the rapidity of drying.

In many cases it is most important that the air used for drying should be properly cleaned.

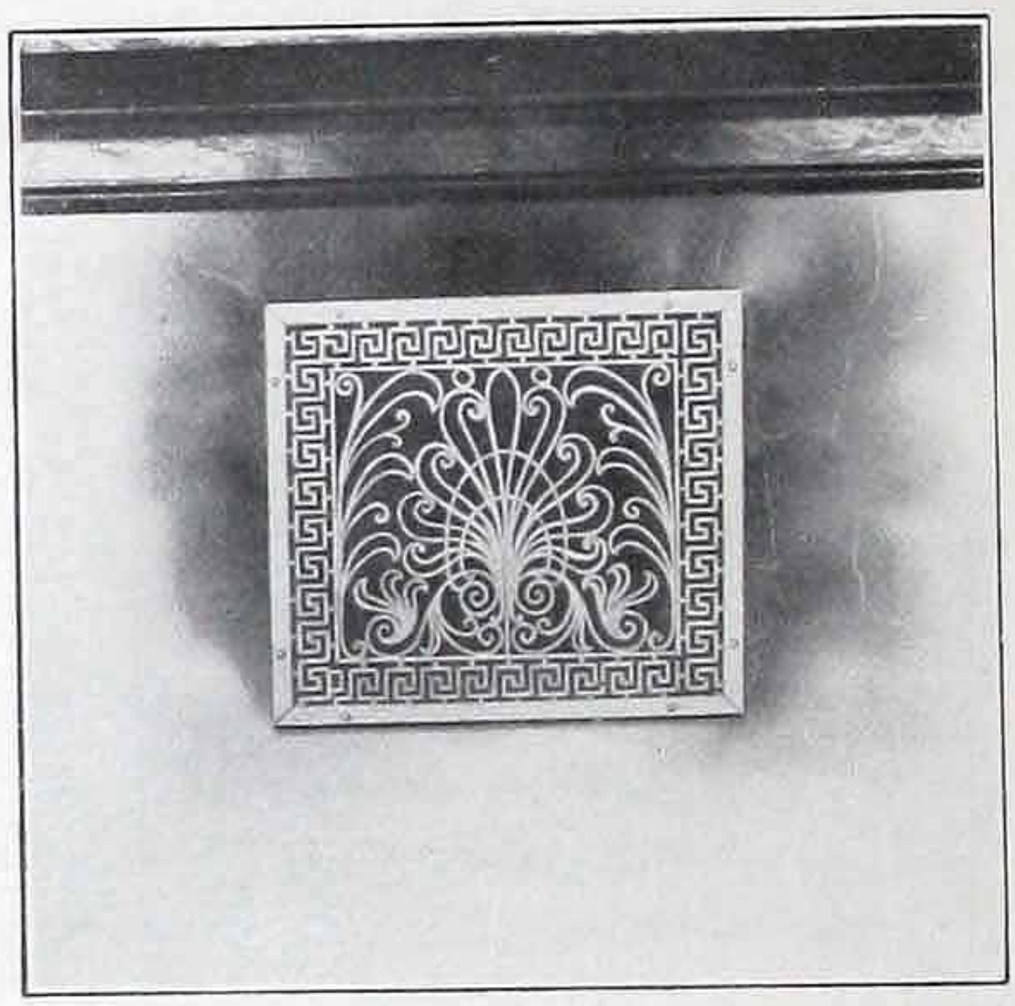
Drying of Terra Cotta, Pottery, Etc.: In the drying of many substances, such as art pottery, terra cotta, and smelting retorts, it is essential that the drying shall be gradual and uniform. In such cases the Carrier Air Washer and Humidifier with the Carrier Automatic Humidity Control is of an inestimable assistance. In such plants the humidity is usually very high at the beginning of the drying and is reduced gradually, allowing the product to dry evenly, uniformly and without cracks, checks, and rendering it less porous than when it drys too rapidly during the first stages.

Low Temperature Drying: Where the nature of the product is such that it is desirable to dry at low temperatures, the Carrier System presents the most economical solution of the problem, as the air is cooled, dehumidified, and then the temperature is slightly raised so it will absorb more moisture.

Among these products whose nature is such as to make it important that they be dried at low temperatures, are photographic films, electrolytic board and glue. Successful installations of the Carrier System in plants of this character are now in operation.



An Arrangement for a School Building



Black and dirty streaks around heating registers on handsomely decorated walls are a common sight. Such unsightly blotches are impossible with the Carrier Air Washer and Humidifier.

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